REPORT

OF THE

SEVENTEENTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

KINGWILLIAMSTOWN.

1919.

JULY 7—12.

JOHANNESBURG:
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1920.

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ASSISTANT GENERAL SECRETARY.

J. W. Stark, Cape of Good Hope Savings Bank Buildings, St. George's Street, Capetown. P.O. Box 1497. (Telegraphic Address: "Scientific.")

ORDINARY MEMBERS OF COUNCIL.

I. CAPE PROVINCE.

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Potchefstroom.

E. Holmes Smith, B.Sc.

III. ORANGE FREE STATE.

Bloemfontein.

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Prof. M. M. Rindl, Ing.D.

IV. NATAL.

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Bulawayo.

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VI. MOZAMBIQUE.

S. Seruya.

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T. W. Jagger, F.S.S., M.L.A.
W. Runciman, M.L.A.

S.A. Medal Fund.

J. de V. Roos, B.A., LL.B.
W. Thomson, M.A., B.Sc., LL.D. F.R.S.E.
W. J. Viljoen, M.A., L.N.C., Ph.D.

A

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As amended at the Seventeenth Annual Meeting at Kingwilliamstown,* 1919.]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) Institutions, Societies, Government Departments and Public Bodies are eligible as "Institutional Members."

(*c*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), (c) Institutional Members, and (d) Temporary Members, elected for a session, hereinafter called "Associates."

(*d*) Members, Institutional Members, and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*e*) The Council shall have the power, by a two-thirds vote, to remove the name of a member of any class whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission,* their Annual Subscription.

(*c*) Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary members; and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.

(*d*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*e*) Members and Institutional Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Ten Pounds.

(*b*) Ordinary and Institutional Members shall pay, on election, an Annual Subscription of One Pound. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Five Pounds in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Session shall be Ten Shillings.

V.—MEETINGS.

The Association shall meet in Session Annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries, the General Treasurer, and the Editor of the publications of the Association, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries, General Treasurer, and the Editor of the publications of the Association shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than 20 Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together

with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such Meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries, for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Johannesburg.

* The Reception Committee should make arrangements to provide :—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Four rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography, Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology;

Political Economy; Sanitary Science; Sociology; Statistics, Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Session before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of Rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee" on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council.

II.—Duties.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution reads as follows:—

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancenent of Science.

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, 2½ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby, in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Chapter XIV. of the Association's Constitution, reading:—

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will *ipso facto* forfeit his seat on the Committee.

B. The Goold-Adams Medals.*

(*a*) The Medals shall be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects; (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Matriculation Examination and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

BYE-LAWS

I. *Bye-laws under which the O.F.S. Philosophical Society was incorporated, from 1st July, 1914, with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.*

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for purposes of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Capetown, and subscriptions to be paid to the General Treasurer of the Association at Capetown, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association, to receive its Journal, and to enjoy the full privileges of membership, as soon as their subscription of £1 for the financial year 1914-15 shall have been paid.

* The award of these medals is at present suspended.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso*, in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

II. Bye-laws for the guidance of Sectional Officers.

1. The attention of all Sectional Officers is directed to Chapter XIII. of the Association's Constitution, relating to the Sectional Committees and their functions.

2. The President and Recorder (or Secretary) of a Section shall have power during the Annual Session to act on behalf of the Section in any matter of urgency which cannot be brought before the consideration of the whole Sectional Committee; and they shall report such action to the next meeting of the Sectional Committee.

3. The President of the Section, or, in his absence, one of the two Vice-Presidents, shall preside at all meetings of the Section or of the Sectional Committee.

4. The President of the Section is expected to prepare a Presidential Address, which shall be delivered during the Annual Session.

5. Prior to the commencement of the Session, the Recorder of each Section shall prepare a list of all papers notified to be read during the Session, and shall also keep the Assistant Secretary of the Association informed of the titles and authors of all such papers. The Assistant Secretary shall, on his part, keep the Recorder informed of all papers that may be notified to him direct.

6. When a proposal is made for the reading of a paper at a joint meeting of Sections, the President, Recorder and Secretary of each Section shall *ex officio* attend a meeting convened by a General Secretary to consider the same.

7. During the continuance of the Annual Session, the Local Secretary of each Section shall be responsible for the punctual transmission to the Assistant Secretary of the daily programme of his Section for early publication, and of any other recommendations adopted by the Sectional Committee; and shall, at the close of the Session, furnish the Assistant Secretary with a list, showing which of the papers notified for reading before the Section have been so read, and which have been taken as read, and giving the dates in either case. He shall, at the same time, indicate the recommendations of the Sectional Committee with respect to each paper, *i.e.*, whether it should be printed in full, or in abstract, or by title only.

8. Each Sectional Committee shall cause to be prepared a record of the discussion on each paper read at its meetings; and

such record shall be attached to the paper and handed in with the same in terms of Clause 11 of these instructions.

9. Each Sectional Committee shall, during the continuance of the Annual Session, meet daily, unless otherwise determined, to complete the arrangements for the next day.

10. In deciding on any recommendation regarding the printing of or otherwise of a paper submitted to it, the Sectional Committee shall consider only the merits of the paper, and not the financial condition of the Association.

11. The Local Secretary of each Section shall, at the close of each day, collect the papers that have been read and hand them to the Assistant Secretary, together with a note explaining the cause of absence of any paper not so handed over.

12. Sectional Officers shall do their utmost to ensure punctual commencement and termination of the Section's daily proceedings; and, in drafting the programme for the next day, the Committee shall endeavour to allot a specified time to the reading and discussion of each paper, in order to prevent other Sections or the Association as a whole being inconvenienced in consequence of delays.

III.—*Bye-Laws for the Affiliation of Scientific and Kindred Societies.*

Philosophical and Scientific Societies, and other Associations of a kindred character may, on application to, and with the approval of the Council, affiliate with the South African Association for the Advancement of Science on the following conditions:—

1. That as a Society can only be affiliated on the approval of the Council, no minimum of membership of such Society need be specified.

2. That each Society shall pay the Association a minimum fee of £5 for a strength of 50 members or less, and a further £1 for each additional 10 or portion of 10 members.

3. That such Society shall be entitled to one copy of the SOUTH AFRICAN JOURNAL OF SCIENCE for each £1 paid to the Association.

4. That such Society may, if it has a strength of 50 members, be represented on the Council of the Association by its President or such other member as may be nominated for the purpose.

5. That all members of affiliated Societies may join the Association as ordinary members, with full privileges, at a reduced annual subscription of 15s.

6. That affiliated Societies shall be asked to take into consideration the admission of members of the Association into their Societies at a reduced subscription.

7. That papers contributed to affiliated Societies may, on recommendation of both their own Council and that of the Association, be printed in the Association's JOURNAL OF SCIENCE, after which the authors shall be entitled to reprints on the usual terms.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E.— CAPE TOWN, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart, M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. JOHANNESBURG, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. JOHANNESBURG, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. KIMBERLEY, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. DURBAN, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.
H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. GRAHAMSTOWN, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. BLOEMFONTEIN, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. CAPE TOWN, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. BULAWAYO, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.
ARNOLD THEILER, C.M.G., D.Sc. PORT ELIZABETH, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E. LOURENCO MARQUES, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.
Professor RUDOLF MARLOTH, M.A., Ph.D., KIMBERLEY, July 6, 1914.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. PRETORIA, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.
Professor LAWRENCE CRAWFORD, M.A., D.Sc., F.R.S.E. MARITZBURG, July 3, 1916.	Rev. W. Flint, D.D. Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. Prof. J. Orr, B.Sc., M.I.C.E. Sir A. Theiler, K.C.M.G., D.Sc.	Prof. W. N. Roseveare, M.A.
Professor JOHN ORR, B.Sc., M.I.C.E., M.I.Mech.E., STELLENBOSCH, July 2, 1917.	A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. H. E. Wood, M.Sc., F.R.Met.S.	Prof. B. de St. J. van der Riet, M.A., Ph.D.
CHARLES F. JURITZ, M.A., D.Sc., F.I.C. JOHANNESBURG, July 8, 1918.	W. Ingham, M.I.C.E., M.I.M.E. A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. H. E. Wood, M.Sc., F.R.Met.S.	J. A. Foote, F.G.S., F.E.I.S.
Rev. WILLIAM FLINT, D.D. KINGWILLIAMSTOWN, July 7, 1919.	P. Cazalet, M.I.M.M. Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Ingham, M.I.C.E., M.I.M.E. Prof. E. Warren, D.Sc.	F. A. O. Pym.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ..	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town ‡	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ..	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques	J. H. von Hafe.	Prof. J. Orr, J. Vaz Gomes.
1914. Kimberley ..	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H. Dinham-Peren.
1915. Pretoria ..	F. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
1916. Maritzburg ..	Prof. J. Orr, B.Sc., M.I.C.E.	Prof. A. Brown, P. Mesham.
1917. Stellenbosch ..	Prof. W. N. Roseveare. M.A.	Prof. A. Brown, L. Simons.
1918. Johannesburg	Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E.	Prof. A. Brown, Prof. J. P. Dalton.
1919. Kingwilliamstown.	W. Ingham, M.I.C.E., M.I.M.E.	Dr. J. Lunt, T. G. Caink, J. Powell.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ..	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ..	Thos. Quentrall, M.I.Mech.E., F.G.S.	C. E. Addams, H. Simpson.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.

CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.

1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.

CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.

1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

1910. Cape Town ..	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911. Bulawayo ..	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912. Port Elizabeth	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913. Lourenço Marques	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Capt. A. Graça.
1914. Kimberley ..	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915. Pretoria ..	H. Kynaston, M.A., F.G.S.	Dr. H. C. J. Tietz, Prof. D. F. du Toit Malherbe.
1916. Maritzburg. ..	Prof. J. A. Wilkinson, M.A. F.C.S.	Dr. H. C. J. Tietz, Prof. J. W. Bews.
1917. Stellenbosch ..	Prof. M. M. Rindl, Ing.D.	Dr. H. C. J. Tietz, Prof. B. de St. J. van der Riet.
1918. Johannesburg	P. A. Wagner, Ing.D., B.Sc.	Dr. H. C. J. Tietz, Dr. J. Moir.
1919. Kingwilliamstown.	H. H. Green, D.Sc., F.C.S.	Prof. J. A. Wilkinson, T. H. Harrison, W. G. Chubb.

SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.

1903. Cape Town ..	Sir Chas. Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904. Johannesburg *	Lieut.-Colonel Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ..	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbatch, W. Newdigate.

* Forestry added in 1904.

Date and Place.	Presidents.	Secretaries.

BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.

1907. Natal	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910. Cape Town *	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911. Bulawayo ..	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912. Port Elizabeth	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, I. L. Drège.
1913. Lourenço Marques	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B. Botelho.
1914. Kimberley ..	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915. Pretoria ..	C. P. Lounsbury, B.Sc., F.E.S.	C. W. Mally, A. K. Haagner.
1916. Maritzburg. ..	I. B. Pole-Evans, M.A., B.Sc., F.L.S.	C. W. Mally, Prof. E. Warren.
1917. Stellenbosch ..	J. Burtt-Davy, F.L.S., F.R.G.S.	C. W. Mally, C. S. Grobbelaar.

BOTANY, BACTERIOLOGY, AGRICULTURE, AND FORESTRY.

1918. Johannesburg	C. E. Legat, B.Sc.	Dr. E. P. Phillips, J. Burtt-Davy.
1919. Kingwilliamstown.	Ethel M. Doidge, M.A., D.Sc., F.L.S.	Dr. E. P. Phillips, E. W. Dwyer, Dr. G. Rattray.

SECTION D.—ZOOLOGY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.

1918. Johannesburg	Prof. E. J. Goddard, B.A., D.Sc.	C. W. Mally, R. J. Ortlepp.
1919. Kingwilliamstown.	Prof. E. Warren, D.Sc.	C. W. Mally, Dr. J. I. Brownlee, B. H. Dodd.

SECTION E.—ANTHROPOLOGY, ETHNOLOGY, ECONOMICS, SOCIOLOGY, AND STATISTICS.

1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd.

ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, AND NATIVE SOCIOLOGY.

1917. Stellenbosch ..	Rev. N. Roberts.	Rev. E. W. H. Musselwhite, Prof. J. J. Smith.
1918. Johannesburg	Rev. W. A. Norton, B.A., B.Litt.	Rev. E. W. H. Musselwhite, Rev. G. Evans.
1919. Kingwilliamstown.	Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.	Rev. E. W. H. Musselwhite, G. R. Spencer, M. Flemmer.

* Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.

SECTION F.—ARCHÆOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1903. Cape Town ..	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ..	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.

ANTHROPOLOGY, ARCHÆOLOGY, ECONOMICS, EDUCATION ETHNOLOGY. HISTORY, PSYCHOLOGY, PHILOLOGY, SOCIOLOGY, AND STATISTICS.

1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

ARCHÆOLOGY, EDUCATION, HISTORY, PSYCHOLOGY, AND PHILOLOGY.

1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1909. Bloemfontein	Hugh Gunn, M.A.	C. G. Grant, Rev. W. A. Norton.
1910. Cape Town ..	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo ..	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques	J. A. Foote, F.G.S.	H. Pim, J. Elvas.
1914. Kimberley ..	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria ..	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.
1916. Maritzburg ..	M. S. Evans, C.M.G., F.Z.S.	Prof. R. D. Nauta, Prof. O. Waterhouse.

EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY, AND STATISTICS.

1917. Stellenbosch ..	Rev. B. P. J. Marchand, B.A.	Prof. R. D. Nauta, Dr. Bertha Stoneman.
1918. Johannesburg	Prof. T. M. Forsyth, M.A., D.Phil.	Prof. R. D. Nauta, J. Mitchell.
1919. Kingwilliamstown.	Prof. R. Leslie, M.A., F.S.S.	Prof. R. D. Nauta, J. Wood, F. J. Cherrigh.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion — Present and Future.
1906. Kimberley ..	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ..	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy
Durban. ..	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1910. Cape Town ..	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ..	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform — Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.
1912. Port Elizabeth	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques	S. Seruya.	The history of Portuguese conquest and discovery.
1914. Kimberley ..	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their discovery, and their relation to other volcanic vents in South Africa.
1915. Pretoria .	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The gold bearing conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House fly under South African conditions.
1916. Maritzburg ..	C. P. Lounsbury, B.Sc., F.E.S.	Scale Insects and their travels.
Durban	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1917. Stellenbosch ..	H. E. Wood, M.Sc., F.R.Met.S.	Some unsolved problems of Astronomy.
	Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S.	Some marine animals of South Africa.
1918. Johannesburg	Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S.	Evolution and Mankind.
	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.	Ostriches.
1919. Kingwilliamstown.	Prof. E. J. Goddard, B.A., D.Sc.	The Approaching South African Antarctic Expedition.
East London	Prof. G. E. Cory, M.A.	Early history of Kaffraria and

GENERAL MEETINGS AT KINGWILLIAMSTOWN.

On *Monday, July* 7, at 11 a.m., the Association was officially welcomed by His Worship the Mayor of Kingwilliamstown (Councillor Col. S. R. Style, M.B.E., J.P.) and Borough Council in Dale College Hall.

At 8 p.m., Members of the Association attended a reception and conversazione, held by His Worship the Mayor of Kingwilliamstown, in the Town Hall.

Thereafter Dr. C. F. Juritz, M.A., F.I.C., resigned the office of President to the Rev. W. Flint, D.D., who took the chair and delivered an address, for which see page 1.

The President subsequently presented the South Africa Medal to Dr. J. Moir, M.A., F.I.C. For the proceedings see page xxxviii.

On *Tuesday, July* 8, at 9 a.m., Members proceeded on a motor trip to the Pirie Forest and Trout Hatchery.

At 8.15 p.m., Members were present at an entertainment given in the Town Hall by the Kingwilliamstown Amateur Musical and Dramatic Society.

On *Wednesday, July* 9, at 10.30 a.m., the Seventeenth Annual General Meeting was held in the Dale College Hall, for Minutes of which see page xxiv.

At 8.15 p.m., in the Town Hall, Professor E. J. Goddard, B.A., D.Sc., delivered a discourse on "The Approaching South African Antarctic Expedition," the President of the Association presiding.

On *Thursday, July* 10, at 8.30 a.m., Members proceeded by railway train to East London.

GENERAL MEETINGS AT EAST LONDON.

On *Thursday, July* 10, at 2.30 p.m., the Association was officially welcomed by His Worship the Mayor of East London (Councillor James Stewart, M.L.A.), in Selborne College Hall.

At 8 p.m., Members of the Association attended a reception, held by His Worship the Mayor of East London, in the City Hall.

On *Friday, July* 11, at 10.30 a.m., Members of the Association visited the Municipal Waterworks Construction Works.

At 2.30 p.m., Members visited the Harbour and Buffalo River Mouth.

At 8 p.m., in the City Hall, Prof. G. E. Cory, M.A., delivered a discourse on "The Early History of Kaffraria and East London," the President of the Association presiding.

On *Saturday, July* 12, at 10 a.m., Members proceeded on an excursion up the Buffalo River to Green Point.

At 2 p.m., Members proceeded on a motor trip to Gonubie Park Estate.

At 8 p.m., in the City Hall, Prof. E. J. Goddard, B.A., D.Sc., repeated his discourse on "The Approaching South African Antarctic Expedition," Mr. J. A. Foote, F.G.S., General Secretary of the Association, presiding.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, KINGWILLIAMSTOWN, 1919.

LOCAL COMMITTEE.

Chairman, James Leighton, F.R.H.S.; J. I. Brownlee, M.B., C.M., E. W. Dwyer, B.A., J. Wood, M.A., T. H. Harrison, Rev. J. A. Campbell, T. G. Caink, M.Inst.M. & C.E., Julian Vowles, M.S.A.I.E.E., H. B. Hutton, G. Ross Spencer, L.D.S., H. Squire Smith, J. G. Weir, H. S. Dyer, Miss C. E. Vaughan, G. A. Nettleton, F. C. Barnes, J. Nicol, M.R.C.V.S., Dr. A. W. Roberts, Major R. Ballantine, M.P.C., H. M. G. Roberts, F. C. L. Vogts, J. C. McCurdy, Principal Alex Kerr, E. J. C. Woodrow, W. A. Owen, Rev. F. J. Sutton, H. G. Flanagan, F.L.S., F. Ginsberg, Rev. W. Eveleigh. *Local Secretary,* F. A. O. Pym.

BRANCH LOCAL COMMITTEE AT EAST LONDON.

Chairman, Dr. E. Hill, L.R.C.P., M.O.H.; John Carrington, John Powell, M.Inst.M. & C.E., Marius T. Flemmer, Will Crosby, B. H. Dodd, M.A., John Bissecker, G. Rattray, M.A., D.Sc., John Mordy Lambe, D. McMillan, J.P., H. C. Peacock, Ben Myers, H. C. Hessenauer, L.D.S., S. T. Wakefield, B.A., E. R. Grey, B.A., M.D., C.B., H. J. C. Cordeaux, F.R.I.S.A., W. G. Chubb, B.A., LL.B., J. M. Orpen. *Local Secretary,* W. H. Wormald, F.R.H.S.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor of Kingwilliamstown (Col. S. R. Style, M.B.E., J.P.); Councillors W. M. Lewis, J. P. H. Mullin, Major C. T. Rayner, J. Mowlem, H. M. G. Roberts, R. Symons, B. O. Schonegevel, J. P. Cumming, J. W. Bryson, A. R. Burton, Mrs. W. T. Randall, Miss Squire Smith, Messrs. S. S. McIntyre, W. Byron, J. H. O'Connell, H. G. Perks, J. G. Weir, T. S. Moodie, W. L. Higgs, A. B. Brown, J. Clarke, A. S. Weir, E. W. Turner, H. Hanrahan, Alfred Everitt. *Secretary,* E. J. C. Woodrow.

RECEPTION COMMITTEE AT EAST LONDON.

Chairman, His Worship the Mayor of East London (Councillor James Stewart, M.L.A.); Councillors M. T. Flemmer, Dr. P. P. J. Ganteaume, M.B.E., Dr. J. Bruce-Bays, A. E. Deary, N. F. Middleton, G. W. Prior, A. P. Dallas, A. H. King, J. F. Pearse, D. D. Nisbet, C. J. Neale; Rev. Cardross Grant, Miss A. McKay, Mrs. Wormald; E. Dowding, M.B.E., J.P.

SECTIONAL COMMITTEES.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND IRRIGATION.

President, W. Ingham, M.I.C.E., M.I.M.E.; *Vice-Presidents,* Prof. R. A. Varder, M.A., and H. E. Wood, M.Sc., F.R.Met.S.; *Members,* T. G. Caink, M.Inst.M. & C.E., M.R.San.I., P. Cazalet, M.I.M.M., Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Lt.-Col. J. H. Dobson, D.S.O., M.Sc., M.I.Mech.E., M.I.E.E., A.M.I.C.E., C. J. Gyde, A.M.I.C.E., R. T. A. Innes, F.R.A.S., F.R.S.E., J. Kirkland, M.Am.I.E.E., Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E., N. Mudd, M.A., J. J. Niven, M.I.C.E., M.R.San.I., Prof. J. Orr, O.B.E., B.Sc., M.I.C.E., M.I.Mech.E., A. H. Reid, F.R.I.B.A., F.R.San.I., A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E., and Prof. W. N. Roseveare, M.A. *Hon. Secretaries,* J. Lunt, D.Sc., F.I.C., (*Recorder*), T. G. Caink, M.Inst.M. & C.E., and J. Powell, M.Inst.M. & C. E.

SECTION B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY, AND GEOGRAPHY.

President, H. H. Green, D.Sc., F.C.S.; *Vice-Presidents,* Prof. G. E. Cory, M.A., and J. Moir, M.A., D.Sc., F.I.C., *Members,* J. Gray, F.I.C., C. F. Juritz, M.A., D.Sc., F.I.C., Prof. D. F. du T. Malherbe, M.A., Ph.D., E. T. Mellor, D.Sc., M.I.M.M., F.G.S., Prof. M. M. Rindl, Ing.D., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., H. C. J. Tietz, M.A., Ph.D., and P. A. Wagner. Ing.D., B.Sc. *Hon. Secretaries,* Prof. J. A. Wilkinson, M.A., F.C.S. (*Recorder*), T. H. Harrison, and W. G. Chubb.

SECTION C.—BOTANY, BACTERIOLOGY, AGRICULTURE, AND FORESTRY.

President, Ethel M. Doidge, M.A., D.Sc., F.L.S. *Vice-Presidents,* Prof. J. W. Bews, M.A., D.Sc., and Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. *Members,* Augusta V. Duthie, M.A., I. B. Pole Evans, M.A., D.Sc., F.L.S., Prof. J. M. Hector, B.Sc., C. E. Legat, B.Sc., Prof. A. I. Perold, B.A., Ph.D., Prof. G. Potts, M.Sc., Ph.D., Ven. Archdeacon F. A. Rogers, T. R. Sim, E. Holmes Smith, B.Sc., Edith L. Stephens, B.A., F.L.S., and Prof. H. A. Wager, A.R.C.S. *Hon. Secretaries,* E. P. Phillips, M.A., D.Sc., F.L.S. (*Recorder*), E. B. Dwyer, B.A., and G. Rattray, M.A., D.Sc.

Section D.—ZOOLOGY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.

President, Prof. E. Warren D.Sc. *Vice-Presidents,* Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S., and Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S. *Members,* T. F. Dreyer, B.A., Ph.D., F. W. FitzSimons, F.Z.S., F.R.M.S., Prof, J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Prof. E. J. Goddard, B.A., D.Sc., J. Hewitt, B.A., Prof. W. A. Jolly, M.B., Ch.B., D.Sc., C. P. Lounsbury, B.Sc., F.E.S., R. E. Montgomery, M.R.C.V.S., Annie Porter, D.Sc., F.L.S., Sir A. Theiler, K.C.M.G., D.Sc., and W. Watkins-Pitchford, M.D., F.R.C.S. *Hon Secretaries,* C. W. Mally, M.Sc., F.E.S., F.L.S. (*Recorder*), Lieut.-Col. J. I. Brownlee, D.S.O., M.B., C.M., and B. H. Dodd, M.A.

Section E.—ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, AND NATIVE SOCIOLOGY.

President, Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S., *Vice-Presidents,* Hon. Justice C. G. Jackson and C. T. Loram, M.A., LL.B., Ph.D. *Members,* Rev. S. G. G. Aitchison, M.A., D.D., Rev. S. S. Dornan, M.A., Rev. G. Evans, Rev. W. A. Norton, B.A., B.Litt., Rev. N. Roberts, and S. Seruya. *Hon. Secretaries,* Rev. E. W. H. Musselwhite, B.A. (*Recorder*), G. Ross Spencer, L.D.S., and M. Flemmer.

Section F.—EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY, AND STATISTICS.

President, Prof. R. Leslie, M.A., F.S.S. *Vice-Presidents,* Prof. R. A. Lehfeldt, B.A., D.Sc., and Prof. W. A. Macfadyen, M.A., LL.D. *Members,* Prof. F. Clarke, M.A., Prof. J. Finlay, Prof. T. M. Forsyth, M.A., D.Phil., J. W. Jagger F.S.S., M.L.A., Prof. W. M. Macmillan, B.A., B. M. Narbeth, B.Sc., F.C.S., H. C. Reeve, M.A., Bertha Stoneman, D.Sc., H. A. Trubshaw, Prof. W. Watkin, M.A., L. ès L., Ph.D., and Prof. O. Waterhouse, M.A. *Hon. Secretaries,* Prof. R. D. Nauta (*Recorder*), J. Wood, M.A., and F. J. Cherrigh.

PROCEEDINGS OF THE SEVENTEENTH ANNUAL GENERAL MEETING OF MEMBERS.

(*Held in the Dale College, Kingwilliamstown, on Wednesday, July 9, 1919.*)

PRESENT: Rev. W. Flint, D.D. (President), in the chair; C. Graham Botha, Dr. J. I. Brownlee, T. G. Caink, Prof. G. E. Cory, Prof. J. E. Duerden, E. W. Dwyer, Dr. I. B. Pole Evans, Rev. W. Eveleigh, Prof. H. B. Fantham, H. G. Flanagan, Prof. T. M. Forsyth, F. Ginsberg, Prof. E. J. Goddard, Dr. H. H. Green, T. H. Harrison, J. E. Hart, J. E. Holloway, J. Hutcheon, W. Ingham, A. J. T. Janse, Principal A. Kerr, Rev. J. R. L. Kingon, J. Leighton, Prof. R. Leslie, Dr. J. Lunt, Rev. J. A. MacColl, Prof. W. A. Macfadyen, A. S. MacIntyre, Mrs. A. W. Marchand, Dr. B. de C. Marchand, J. Mitchell, Dr. J. Moir, Adv. G. T. Morice, Prof. C. E. Moss, Rev. E. W. H. Musselwhite, Prof. J. Orr, Dr. E. P. Phillips, Miss E. D. Pocock, Dr. Annie Porter, F. A. O. Pym, Dr. A. Pyper, S. G. Rich, P. Stein, J. D. Stevens, Rev. F. J. Sutton, H. A. Trubshaw, Prof. R. W. Varder, Prof. H. A. Wager, Prof. E. Warren, Prof. Morgan Watkin, W. A. Way, Prof. J. A. Wilkinson, H. E. Wood, J. Wood, E. J. Woodrow, Miss K. M. Wright; Dr. C. F. Juritz and J. A. Foote (General Secretaries), and J. W. Stark (Assistant General Secretary).

MINUTES.—The Minutes of the Sixteenth Annual General Meeting, held at Johannesburg, on 11th July, 1918, and printed on pp. xiv to xviii of the Report of the Johannesburg Session, were confirmed.

ANNUAL REPORT OF THE COUNCIL.—The Annual Report of the Council for 1918-19 having been suspended in the Registration Room since the 7th July, was taken as read and adopted, on the motion of Prof. J. E. Duerden. (See p. xxviii.)

REPORT OF GENERAL TREASURER AND STATEMENT OF ACCOUNTS FOR 1918-19.—The General Treasurer's Report and the audited Financial Statement for the year ended 31st May, 1919, having been suspended in the Registration Room since 7th July, were taken as read and adopted, on the motion of Mr. W. Ingham.

ALTERATION IN CONSTITUTION.—*Headquarters of Association.*—Prof. Moss moved, in accordance with notice:—

> That "Johannesburg" be substituted for "Capetown" in Rule VIII of the Constitution.

This was seconded by Prof. Dr. J. E. Duerden.

Dr. J. Lunt moved as an amendment:—

> That the decision on the proposal to remove the Headquarters be postponed until the next Annual Meeting, for the purpose of obtaining and circulating among the members information as to the additional cost (if any) of carrying on the work of the Association which would be involved in the change, and that arrangements be made for ascertaining the opinion of all the members by a vote in accordance with Rule XV by the circulation of voting papers in time for the 1920 meeting.

Prof. G. E. Cory seconded the amendment. After considerable discussion the amendment was put, when 19 voted in favour of it and 33 against. The amendment was therefore declared lost. Prof. Moss's motion being put, 34 voted for and 18 against it. The Chairman declared the motion carried.

Election of Officers for 1919-20.—The following Officers were elected for 1919-20:—

President, Iltyd Buller Pole Evans, M.A., D.Sc., F.L.S.; Vice-Presidents, Prof. J. W. Bews, M.A., D.Sc., Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S., Prof. R. Leslie, M.A., F.S.S., Prof. J. A. Wilkinson, M.A., F.C.S.; General Secretaries, C. F. Juritz, M.A., D.Sc., F.I.C., and J. A. Foote, F.G.S., F.E.I.S.; General Treasurer, Prof. C. E. Moss, M.A., D.Sc., F.L.S., F.R.G.S., Editor of Publications, C. F. Juritz, M..A, D.Sc., F.I.C.

Election of Council Members for 1919-20.—The following were elected members of Council for 1919-20 (the retiring President, Rev. Dr. W. Flint, being also *ex officio* a member of the Council for the year):—

I. Cape Province.—(1) *Cape Peninsula*: Prof. L. Crawford, M.A., D.Sc., F.R.S.E., J. Lunt, D.Sc., F.I.C., C. W. Mally, M.Sc., F.L.S., F.E.S., Rev. W. A. Norton, B.A., B.Litt., A. H. Reid, F.R.I.B.A., F.R.San.I., A. Walsh. (2) *East London*: E. Hill, L.R.C.P., M.R.C.S., D.P.H. (3) *Kimberley*: Miss M. Wilman. (4) *Kingwilliamstown*: J. Leighton, F.R.H.S., E. B. Dwyer, B.A. (5) *Middelburg*: W. J. Lamont. (6) *Port Elizabeth*: J. Hewitt, B.A., Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S. (7) *Stellenbosch*: Prof. E. J. Goddard, B.A., D.Sc., Miss Alta Johnson, Ph.B.

II. Transvaal.—(1) *Witwatersrand*: P. Cazalet, M.I.M.M., Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S., F. Flowers, C.E., F.R.G.S., F.R.A.S., J. Gray, F.I.C., W. Ingham, M.I.C.E., M.I.M.E., R. T. A. Innes, F.R.A.S., F.R.S.E., E. T. Mellor, D.Sc., M.I.M.M., F.G.S., J. Mitchell, J. Moir, M.A., D.Sc., F.I.C., Prof. J. Orr, O.B.E., B.Sc., M.I.C.E., M.I.Mech.E., Annie Porter, D.Sc., F.L.S., Ven. Archdeacon F. A. Rogers, S. Seruya, Prof. M. Watkin, M.A., L.ès L., Ph.D., H. E. Wood, M.Sc., F.R.Met.S. (2) *Pretoria*: Ethel M. Doidge, M.A., D.Sc., F.L.S., H. H. Green, D.Sc., F.C.S., A. J. T. Janse, F.E.S., P.A. Wagner, Ing.D., B.Sc. (3) *Potchefstroom*: F. G. Tyers, M.A.

III. Orange Free State (including Basutoland).—Prof. T. F. Dreyer, B.A., Ph.D., F. W. Storey, B.Sc., F.C.S.

IV. Natal.—(1) *Durban*: M. S. Evans, C.M.G., F.Z.S., Hon. Senator W. Greenacre. (2) *Maritzburg*: J. S. Henkel, Prof. E. Warren, D.Sc.

No nomination having been received from Rhodesia, the election of a member to represent that centre was left to the Council.

Sir David Gill Memorial.—On the motion of Prof. J. Orr, it was agreed to refer this matter to the Council, with power to adopt a definite scheme and to collect money for this object.

PROPOSAL FOR JOINT PREMISES OF TECHNICAL AND SCIENTIFIC SOCIETIES IN JOHANNESBURG.—Mr. W. Ingham moved:—

(1) That this meeting approves of the principle of joint housing of technical and scientific societies on the Rand.

(2) That this meeting appoints two members to represent this Association on a joint committee to consider this question, this resolution not to involve any financial responsibility.

This was seconded by Prof. Wilkinson, and carried.

Prof. J. Orr and Prof. M. Watkin were then appointed to represent this Association on the joint committee.

SOUTH AFRICAN NATIONAL ANTARCTIC EXPEDITION.—On the proposal of Prof. Goddard, Dr. J. Lunt was appointed to represent the Association on the Financial Committee of the S.A. Antarctic Expedition.

ANNUAL SESSION, 1920.—The President read a letter from His Worship the Mayor of Bulawayo to Prof. J. Orr extending to the Association, on behalf of that town, "a very cordial welcome to hold its annual Congress for 1920 in Bulawayo." On the motion of Dr. Juritz, it was agreed to accept this invitation.

As Prof. Orr was on the point of visiting Rhodesia, it was agreed, on the suggestion of the President, to authorise him to assist in forwarding the arrangements there.

ANNUAL SESSION, 1921.—A letter from Mr. Maurice S. Evans was read by the President, extending an invitation from members at the Durban centre to the Association to hold its annual meeting in 1920 or 1921 at Durban, and stating that the Mayor of Durban desired to associate himself with the invitation. It was agreed to accept this invitation for the 1921 Session.

DESTRUCTION OF ELEPHANTS IN ADDO BUSH.—The Rev. J. R. L. Kingon moved, seconded by Prof. E. Warren:—

That this Association views with great regret the decision of the Provincial Administration to exterminate the herd of Cape elephants, relics of a dying race now preserved in Addo Bush, and strongly urges the desirability, in the interests of science and the future, of retaining at least a small herd of this unique race; that in the judgment of the Association the destruction of the rogue elephants, together with the provision of an adequate supply of water, would effectively serve the purpose, and therefore strongly urges that the Administration should at least give this solution a fair trial before proceeding to the extreme action now proposed.

On the motion of Dr. Pole Evans, it was resolved that the foregoing resolution be referred to the Committee of Section D, to report to the Council meeting on Friday. This was carried.

THE EDITOR'S SERVICES.—On the motion of Mr. W. Ingham, it was resolved:—

That it be an instruction to the new Council to take into immediate consideration the recognition of the excellent services rendered by Dr. Juritz as Editor of the JOURNAL.

VOTES OF THANKS.—On the motion of Mr. J. A. Foote, it was unanimously resolved that the hearty thanks of the Association should be accorded to the following:—

(1) To His Worship the Mayor and Councillors of Kingwilliamstown for the cordial welcome extended to the Association, and for the Reception given to the Members at the Town Hall.

(2) To Prof. Cory, for having organised a motor tour for Members from Grahamstown to Kingwilliamstown, and to the authorities at Lovedale Institution for the entertainment of those Members to luncheon.

(3) To the Local Reception Committees for the excellent arrangements made for the accommodation, comfort and entertainment of the visitors, and for invitations to witness the comedy, "A Pair of Spectacles," by the Local and Amateur Musical and Dramatic Society, in the Town Hall.

(4) To the Municipal Council of Kingwilliamstown, for having arranged a most enjoyable excursion to the Perie Forest, and for the cordial hospitality extended on that occasion.

(5) To the Directors and Manager of the Trout Hatchery for their kind invitation to visit the Hatchery.

(6) To the Council and Principal of the Dale College for placing the College Buildings at the disposal of the Association, and for the satisfactory arrangements there.

(7) To the Ladies of Kingwilliamstown for the admirable arrangements made for morning and afternoon tea.

(8) To the following Institutions for admitting Members as Honorary Members during the period of the meeting:—

The Kingwilliamstown Club.
The Border Club, Kingwilliamstown.
Kingwilliamstown Golf Club.
The Southern Cross Tennis Club.
The Lorraine Tennis Club.
Alexandra Croquet Club.
Prescott Croquet Club.
The Public Library.

(9) To those gentlemen who kindly provided motor cars for the excursions.

(10) To the local Press for its appreciative references to the proceedings of the Session.

(11) To Mr. Henry Sinclair, East London, for assisting to arrange hotel accommodation at East London.

On the motion of Dr. Juritz, an unanimous and very hearty vote of thanks was accorded to the Rev. Dr. W. Flint, the retiring President, for his services during his year of office.

The following additional votes of thanks were subsequently passed at the conclusion of Prof. Cory's evening discourse at East London, on Friday, July 11:—

(1) To His Worship the Mayor and Councillors of East London and Members of the Reception Committee, for the cordial welcome, and for the Reception given to the Members in the City Hall.

(2) To Dr. Hill, Mr. Wormald and Members of the Local Committee for the arrangements made for the accommodation, comfort and entertainment of the visitors.

(3) To the Civic Association for arranging the meeting for Prof. Cory's lecture in the City Hall.

(4) To the Divisional Superintendent of Railways and Harbours, for arranging special convenience for travelling from Kingwilliamstown to East London, and for arranging for the visit to the Harbour and Buffalo River.

(5) To the Town Engineer, for arranging an excursion by motor cars to the Waterworks.

(6) To His Worship the Mayor and City Councillors of East London, for arranging the River Excursion to Green Point.

(7) To Messrs. William Cooper and Nephews, for their kind invitation to Members to visit Gonubie Park Estate.

(8) To the Principal and Council of Selborne College, for placing the commodious College Buildings at the disposal of the Association, and for the satisfactory arrangements made there.

(9) To the Ladies, for the excellent arrangements made for morning and afternoon tea.

(10) To the East London Club, for kindly admitting Members as Honorary Members during the period of the meetings.

(11) To the local Press for its appreciative references to the proceedings of the Session.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1919.

1. Obituary: Your Council has to report, with great regret, the death, from wounds received in action, of Mr. L. H. Walsh. Another member, Dr. R. A. Buntine, M.L.A., lost his life through the torpedoing of the steamship *Galway Castle*. We also deplore the decease of Messrs. E. Jacot and Mr. J. C. Spensley, on active service, and of the Rt. Hon. W. P. Schreiner, Rev. J. Fitz-Henry, Messrs. R. F. Browne, W. H. Daymond, F. Oats, W. F. Cohen, Drs. A. Schulz, W. Mortimer, F. A. Wille, S. B. Syfret, Miss D. Gott and W. S. Marshall.

2. Membership: Since last report 127 new members have joined the Association, 16 have died, and 32 have been removed from the register by resignation or by resolution of the Council. The nett increase of membership has therefore been 79.

The following comparative table, as from the 1st July in

each year, shows the various Provinces from which members are drawn:—

	1918.		1919
Cape Province	215	...	281
Transvaal	390	...	410
Orange Free State	41	...	39
Basutoland	1	...	1
Natal	82	...	82
Rhodesia	19	...	17
Mozambique	9	...	9
South-West Africa Protectorate	1	...	1
Abroad	14	...	21
Unknown	2	...	2
	774		863

The number on the roll of Life Members at present is 84, three having died and three having been added.

3. Report of the Stellenbosch Meeting, 1917: The fourteenth Annual Volume of the Transactions of the Association, comprising the proceedings at the Stellenbosch Session in 1917, has been completed in twelve monthly issues. These have been bound uniformly with the preceding twelve volumes, forming a volume of 645 pages. It contains 64 papers printed in full, 9 in abstract, and 24 by title only.

4. Report of the Johannesburg Meeting, 1918: The current volume is nearing completion, two more issues remaining to be published.

5. Assistant General Secretary: Mr. H. Tucker, after seven years' service as Assistant General Secretary, felt constrained, for reasons of health, to tender his resignation, which was accepted with regret. General appreciation of his services was expressed, and a sum of 25 guineas was presented to him on the expiry of his term of office. He has been succeeded in the office by Mr. J. W. Stark.

6. Affiliation to British Association: No reply has yet been received from the British Association for the Advancement of Science in connection with the application for admission to the privileges of an "Affiliated Corresponding Society," in terms of Chapter XI., Section I, of the British Association's Constitution. It will be recollected that allusion was made to this matter in the report submitted at the Stellenbosch Meeting two years ago.

7. Donations: The thanks of the Association are due to the Rand Mining Houses for the generous contribution of £125 to the Association's publication expenditure, and to Capetown firms and individuals for a similar contribution of £215 5s.; likewise to the Hon. the Minister of Mines and Industries for a grant of £150 towards the same object, and £50 in aid of members' travelling expenses.

8. South Africa Medal and Grant, 1919: On the recommendation of the South Africa Medal Committee, consisting of Dr. C. F. Juritz (Chairman), Principal J. C. Beattie, Prof. J. W. Bews, Dr. W. A. Caldecott, Dr. I. B. Pole Evans, Prof. H. B. Fantham, Mr. C. P. Lounsbury, Mr. R. E. Montgomery, Prof. J. Orr, Prof. M. M. Rindl, Dr. A. W. Roberts and Sir Arnold Theiler, your Council has awarded the South Africa Medal, together with a grant of £56, to Dr. James Moir, M.A., D.Sc., F.I.C., Government Mining Chemist, Johannesburg. A proposal was made to utilise the yearly surplus of the Medal Fund for grants in aid of research, but it was decided that the terms of conveyance did not permit of such a course.

9. Grants for Research: Your Council has appointed Prof. H. B. Fantham, Dr. C. F. Juritz, Mr. H. E. Wood and Rev. Dr. Flint to represent the Association on the Research Grant Committee of the Royal Society. The constitution of a Research Grant Board was notified to Council by the Secretary for Education last December, and in this connection it was suggested that this Association should amalgamate with the Royal Society of South Africa, and that the Board should in future receive the grants for research hitherto made by Government to the Royal Society and to the Association. Your Council, in replying, expressed the hope that the Research Grant Board would give due regard to the making of grants for research in pure science, the proposed amalgamation being held by the general opinion of the Council, after careful consideration, to be impracticable. A deputation waited on the Minister of Mines to solicit the continuance of the annual grant of £150; the request was complied with, and the amount placed on the Estimates, passed by Parliament, and duly paid over to the Association.

10. Comparative Study of Natives: A resolution was adopted by Council, recommending in view of the urgent need of fundamental and thorough comparative study of the Natives of South Africa, the importance of research into Native Philology, Ethnology, Psychology and Sociology, both for the advancement of knowledge and for the practical help of those whose business it is to deal with the Natives. Copies of the resolution were forwarded to the Ministers of Native Affairs and Education and to the Vice-Chancellors of the three Universities. The Research Grand Board, to whom the matter had been referred by the Minister of Education, expressed the view that research into Native Philology, Ethnology, Psychology and Sociology are subjects which fall within the purview of the Board, which would, in dealing with applications concerning them, obtain the advice of experts.

11. Meteorological and Geophysical Research: Mention was made in last report of the appointment of a Standing Committee on Meteorological and Geophysical Research, under the Chairmanship of Prof. J. T. Morrison. No report from this Committee has yet been received.

12. Premises for Learned Societies: On the invitation of the local branch of the British Medical Association, your Council appointed Rev. Dr. Flint and Dr. C. F. Juritz, with the subsequent addition of Mr. C. W. Mally and Prof. Goddard, its representatives on a Joint Committee of Learned Societies to consider the possibility of acquiring or leasing centrally-situated premises in Capetown, for the purpose of accommodating the various learned societies of the Peninsula, together with a joint scientific library, and engaging a whole-time Secretary. The Joint Committee has duly considered the proposal, but it has been left in the hands of the British Medical Association to take the initiative in the event of suitable premises becoming available.

13. Exhibition of Apparatus: After the conclusion of last year's Annual Session, Council resolved that it would be desirable at future Sessions to arrange for the exhibition, at one of the evening functions, of lantern slides, illustrative of papers, original apparatus, specimens and other objects of interest, and recommended that the matter be brought to the notice of the local Committee at Kingwilliamstown.

14. Exhibition at Pretoria: It has been proposed to hold an exhibition at Pretoria—probably in 1920—in connection with the official opening of the Union Buildings. The Mayor of Pretoria having sought the goodwill of the Association in this regard, it was resolved to notify His Worship that the Association was in full sympathy with the proposal, and would do its best to promote the success of the undertaking.

15. Zoological Survey: Consequent upon the resolution adopted at the Annual Meeting at Johannesburg last year, and duly conveyed to the Government, the Advisory Board of Industry and Science was asked by Council to approach the Government in support of the resolution. The Board made representations to Government on the subject, pointing out the importance and urgency of such a survey, and your Council appointed a Sub-committee for the purpose of pressing for the establishment of the survey, since, according to the Board of Industry and Science, the promotion thereof now rests with the Government Departments concerned.

16. Destruction of Fauna: Representations have reached Council on the subject of the proposed systematic destruction of wild animals in Zululand, which it was alleged are active agents in the spread of disease, and of the elephants in the Addo Bush, which are stated to cause damage to farming operations. In the former case it was decided to request the Natal Administration to limit the destruction of game as far as possible, and the Division of Veterinary Research to undertake further studies as to the nature, spread and possible sources of Nagana infection. In his reply the Provincial Secretary of Natal wrote as follows:

"By direction of the Administrator, I communicated with the Secretary for Agriculture on the 11th April, point-

ing out that the time had now arrived when the responsibility of the game for the spread of Nagana should be further enquired into, and if possible finally disposed of. In that minute I questioned whether the annihilation of the game animals without the destruction of all vermin is going to have the desired result, and pointed out that in the end it might be found that the extermination of the game, especially the more beautiful and rarer species, will have been vain and could have been obviated.

"The Director of Veterinary Research has been instructed to visit the principal magisterial centres in the known Tsetse Fly zones, with a view to formulating a definite scheme for enquiry, and Mr. Montgomery has informed me that he proposes visiting Zululand towards the end of this month."

17. Suppression of Venereal Diseases: The resolutions adopted at the last Annual Session were duly conveyed to the Medical Officer of Health for the Union, who replied that these resolutions had been noted for consideration at the Public Health Conference at Bloemfontein. Prof. Rindl and Dr. T. F. Dreyer were subsequently afforded the opportunity of placing the resolutions before the Conference.

18. Sir David Gill Memorial: An endeavour was made to secure contributions towards the local memorial (alluded to in last report) to the late Sir David Gill, first President of this Association, but owing largely to the war conditions, it was decided to hold the matter in abeyance. Council has decided to submit the establishment of a Gill Memorial for consideration at the Annual Meeting in Kingwilliamstown.

19. Wild Flowers Protection Committee, Capetown: Your Council has appointed Mr. C. W. Mally and Dr. C. F. Juritz to represent the Association on this Committee.

20. International Catalogue of Scientific Literature: The Council adopted, and communicated to the Royal Society, the following resolution:—

"That this Association recognises the great importance of the International Catalogue of Scientific Literature, and earnestly trusts that the Royal Society of London will do all in its power to ensure not merely the continuance of the work, but also the speedy recovery of the leeway caused by the war."

21. Reconstitution of the Union Senate: Your Council considered this matter during the recess, and adopted a resolution to the effect that in the future constitution of the Union Senate provision should be made for nominated members to be selected from those having special attainments in Education, Science and Industries.

A deputation of the Council subsequently waited on the Acting Prime Minister, and were informed that the constitution

of the Senate would not be dealt with during the coming Parliamentary Session, and that the Government desired to know whether the Association had considered the question of altering the functions of the Senate if the proposals for its reconstitution were accepted.

22. SIGNING OF THE ARMISTICE: On the occasion of the signing of the Armistice last November, your Council unanimously resolved respectfully to request His Excellency the Governor-General to transmit the following message to His Majesty the King:—

> "The Council of the South African Association for the Advancement of Science desires to convey to His Majesty the King the assurance of its deep loyalty and unswerving devotion to His Majesty's person and throne, and its heartfelt gratification on the conclusion of the Armistice and the prospects of a victorious peace."

The request for transmission was complied with, and in due course a message was received from His Excellency the Governor-General to the effect that the message of congratulation had been laid before His Majesty, who had been pleased to receive it.

23. THE NEW COUNCIL: On the basis of membership provided for in the Constitution of the Association, Section VI (*d*), the number of Members of Council assigned for the representation of each centre during the ensuing twelve months should be distributed as follows:—

Cape Province:	
Cape Peninsula	5
East London...	1
Kimberley	1
Kingwilliamstown	2
Middelburg	1
Port Elizabeth	2
Stellenbosch	2
Transvaal:	
Witwatersrand	15
Pretoria...	4
Potchefstroom	1
Orange Free State:	
Bloemfontein...	2
Natal:	
Maritzburg	2
Durban	2
Rhodesia:	
Salisbury	1
	41

REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDED MAY 31ST, 1919.

The statements submitted show a substantial balance on the year's working. This is mainly due to grants from outside sums, viz.: £150 from Johannesburg Mining Houses towards JOURNAL expenditure, £231 specially collected in Capetown by Prof. Orr, and a Government grant of £50 towards the expenses of the 1918 Annual Meeting. In addition there is still to come in the promised grant of £150 from Government towards the expenses of the Association.

The expenditure includes only eleven numbers of the JOURNAL, and is further diminished by the fact that the Johannesburg claim under Rule 9 was made too late for inclusion in the accounts of the current year. A special item is the bonus authorised by Council to the former Assistant Secretary, Mr. H. Tucker, on his retirement from office.

The estimates for next year should receive careful consideration, as the nominal annual revenue is still short of the expenditure. At present prices the net cost of the JOURNAL for 12 months may be taken as £700, and other expenses as about £300. The revenue may be taken as: Subscriptions £675, interest £80, Government grant £150. Even if the last item be considered as an established source of revenue, there will be a considerable deficit in the year's working. The Council should consider carefully the disposal of the present balance, so as to secure some permanent stability in the finances of the Association.

The Endowment Fund shows an increase of £25 from Life Subscriptions.

The Medal Fund is unchanged in amount, the whole of the available balance being paid to the Medallist of the year.

ALEXANDER BROWN,

Hon. Treasurer.

27th June, 1919.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR YEAR ENDED 31ST MAY, 1919.

Expenditure.

		£ s. d.	£ s. d.
To Assistant Secretary's Salary			120 0 0
„ Rent			30 0 0
„ Journal		698 15 3	
Less Donations from Rand—			
Mining Houses ...	£150 0 0		
Sales and Reprints..	45 19 2		
		195 19 2	
			502 16 1
„ Printing and Stationery			42 9 2
„ Stamps and Telegrams...			18 4 ·8
„ Sundry Charges—			
Caretaker		6 0 0	
Exchange		1 15 6	
Audit		5 5 0	
P.O. Box and Telegraphic Address		2 1 0	
Goold Adams Medals		4 13 10	
Insurance and Petties		1 5 7	
Election Expenses		0 19 8	
Cheque Book and Pass Book ...		0 6 0	
Grants under Rule 9...		4 0 0	
Typewriter Repairs		3 0 0	
			29 6 7
„ Depreciation on Furniture			3 1 0
„ Annual Meeting			42 6 10
„ Bonus to Mr. H. Tucker			26 5 0
„ Balance to Balance Sheet			329 18 8
			£1,144 8 0

Revenue.

	£ s. d.	£ s. d.
By Balance brought forward from 1918...		126 7 9
„ Annual Subscriptions, 1918-1919 ...	616 0 0	
„ Arrear Subscriptions	51 0 0	
		667 0 0
„ Interest on Endowment Fund... ...		71 0 3
„ Special Collection in Capetown ...		231 0 0
„ Special Government Grant		49 0 0
		£1,144 8 0

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BALANCE SHEET AS AT 31ST MAY, 1919.

Liabilities.	£	s.	d.	Assets.	£	s.	d.	£	s.	d.
To Capital Account ...	329	18	8	Trustees of Medal Fund ...				1,445	13	8
„ Medal Fund ...	1,445	13	8	Trustees of Endowment Fund ...				1,575	0	3
„ Endowment Fund ...	1,573	0	0	Cape of Good Hope Savings Bank—Deposit ...				300	10	0
„ Subscriptions paid in Advance ...	33	10	0	Cash—Standard Bank of South Africa, Ltd.				38	10	3
„ Library Deposits ...	5	0	0	Furniture ...	30	9	2			
				Less Depreciation ...	3	1	0			
								27	8	2
	£3,387	2	4					£3,387	2	4

I hereby certify that I have examined the above Balance Sheet and Revenue Account with the Books, Vouchers, and Banker's Pass Book relating thereto, and that in my opinion they correctly set forth a true and correct statement of the affairs of the Association as shown by the books thereof.

ALEXANDER BROWN,
Treasurer.

HY. GIBSON,
Incorporated Accountant,
Certified Accountant (Cape).

Capetown, 27th June, 1919.

SOUTH AFRICA MEDAL FUND.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MAY, 1919.

	£	s.	d.		£	s.	d.
To award to Dr. J. Moir ...	56	0	10	By Balance at 1st June, 1918 ...	1,445	13	8
„ Engraving Medals and Typing..	1	8	3	„ Interest ...	57	9	1
„ Balance at May 31st, 1919 ...	1,445	13	8				
	£1,503	2	9		£1,503	2	9

SOUTH AFRICAN ASSOCIATION FOR ADVANCEMENT OF SCIENCE.

ENDOWMENT FUND

For Year ended 31st May, 1919.

	£	s.	d.		£	s.	d.
To Interest paid to General Account	68	10	0	By Balance at 1st June, 1918	1,548	0	0
„ Balance at 31st May, 1919	1,573	0	0	„ Life Subscriptions	25	0	0
				„ Interest	68	10	0
	£1,641	10	0		£1,641	10	0

Hy. Gibson,
Incorporated Accountant,
Certified Accountant (Cape).

LEDGER BALANCES, 31st MAY, 1919.

		£	s.	d.	£	s.	d.
4	Revenue and Expenditure Account ...				329	18	8
22	Endowment Fund				1,573	0	0
24	Endowment Fund—Trustees' Account..	1,575	0	3			
28	Furniture	27	8	2			
42	S.A. Medal Fund				1,445	13	8
44	S.A. Medal Fund—Trustees' Account..	1,445	13	8			
71	Library Deposit Account..				5	0	0
79	Cape of Good Hope Savings Bank ...	300	10	0			
83	Subscriptions, 1919-1920...				33	10	0
164	Standard Bank	38	10	3			
		£3,387	2	4	£3,387	2	4

TWELFTH AWARD OF THE SOUTH AFRICA MEDAL AND GRANT.

(Fund raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidential Address in the Dale College Hall, Kingwilliamstown, on Monday, July 7, 1919, the President, Rev. Dr. W. Flint, handed the South Africa Medal, together with a grant of £56, to Dr. JAMES MOIR, M.A., D.Sc., F.I.C., Government Mining Chemist. In making this presentation the President said:—

Dr. Moir was educated at Aberdeen University, and took his B.Sc. degree in 1895 with special distinction in Chemistry. In 1897 he obtained M.A. and B.Sc. of the University simultaneously with 1st Class Honours in Chemistry, Mathematics, and Natural Philosophy.

From 1897 to 1900 he did research work in Organic Chemistry at Aberdeen, and gained the 1851 Exhibition Scholarship. He continued research in London at the City and Guilds Central Technical College from 1900 to 1902.

In 1902 he gained the D.Sc. degree of Aberdeen, dividing with Mr. (now Professor) Findlay the prize for the most distinguished graduate of the year. In the same year he came to South Africa, and two years later became Chemist to the Transvaal Mines Department.

Since Union he has occupied the post of Government Mining Chemist.

The following is a list of Dr. Moir's published papers:—

1. "Constitution of Amarine and allied iminazole compounds."
2. "Pyridine derivatives from condensation of acetonitrile." 1900-1902.
3. "Di-indigotine, the diphenyl-analogue of indigo."
4. "Miners' Phthisis investigations." (Transvaal Government Bluebook), 1903.
5. "Colorimetric estimation of gold in cyanide solution." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1903).
6. "The Cyanide process from the standpoint of modern Chemistry." *Report S.A. Assoc. for Adv. of Science* (1904).
7. "The states of combination of zinc in working cyanide solutions." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1904).
8. "Carbon monoxide and other gases of tobacco smoke." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1904).
9. "Rusting corrosion of steel and galvanising." (Two notes.) *Journ. Mech. Engineers of S. Africa* (1904-5).
10. "Solubility of zinc hydrate in caustic soda." *Rept. Brit. Assoc. for Adv. of Science* (1905).
11. "Vitiation of Transvaal Mine Air." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1905).
12. "Fumes from burnt explosives and physiological action of nitrous acid." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1906).
13. "Thiocarbamide—a new solvent for gold." *Journ. Chem. Soc.* and *Journ. Chem. Metall. & Mining Soc. of S. Africa* (1906).
14. "Constitution of Cerulignone." *Proc. Chem. Soc.* (1906).
15. "New derivatives of diphenol." *Journ. Chem. Soc.* (1906).

The South African Medal

16. "So-called chromate of benzidine." *Proc. Chem. Soc.* (1906).
17. "New method of determining halogens in organic combination." *Journ. Chem. Soc.* (1906-1907).
18. "Recent investigations on Rand Mine Air." *Journ. Chem., Metall. & Min. Soc. of S. Africa* (1906).
19. "Recent investigations on Rand Mine Air (Part II), with notes on standards of purity of air."
20. "New law connecting mine ventilation with wet-bulb temperature." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1907).
21. "New method of estimating mercury as a sophistication of explosives." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1908).
22. "Summary of known data on Mine Air for Mining Regulations Commission, 1908." Government Blue-book (1910).
23. "Experimental evidence of presence of carbon monoxide in mines after blasting." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
24. "The Spectrum of the Ruby." *Trans. Royal Soc. S. Africa* (1909).
25. "Sensitive detection of potassium by means of dyed gelatine films." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
26. "Suggestions for a new atomic theory. *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
27. "Action of moist air on quicklime." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
28. "Experiments on cyanide chemistry." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
29. "Properties of aurocyanic acid." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1909).
30. "A method of harmonising the atomic weights." *Trans. Chem. Soc.* (1909).
31. "Genetic connections between the Chemical Elements." *Report S.A. Assoc. for Adv. of Science* (1910).
32. "New sensitive test for hydrocyanic acid." *Proc. Chem. Soc.* (1910).
33. "New views on Stereochemistry." (Pres. Address.) *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1910).
34. "The Destruction of Cyanide and the Ferrocyanide reaction" (with J. Gray). *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1910).
35. "Sensitiveness of tests for hydrocyanic acid in air." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1910).
36. "Colloidal Gold and Purple of Cassius." *Trans. Royal Soc. S. Africa* (1911).
37. "Blue oxidation-products of benzidine." *Trans. Royal Soc. S. Africa* (1911).
38. "Further investigation on the Ruby and artificial Ruby." *Trans. Royal Soc. S. Africa* (1911).
39. "Spectrum of the Emeralds and other Gem stones." *Trans. Royal Soc. S. Africa* (1911).
40. "Chemistry and crystallography." *Report S.A. Assoc. for Adv. of Science* (1911).
41. "New kind of Stereoisomerism in the diphenoquinones." *Report S.A. Assoc. for Adv. of Science* (1912).
42. "Theory of Coal Calorimetry." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1911).
43. "Thymolphthalein for air-testing for CO_2." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1912).
44. "A plea for an improved heat-test for Explosives." *Report Internat. Congress of Applied Chemistry* (1912).
45. "Atomic weights and new theory of affinity." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1912).
46. "Analysis of Tshisa stick fumes for NO_2," *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1912).

47. "Examination of Indicators for Lime Estimations" (with J. Gray). (Two papers.) *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1912 and 1913).
48. "Oxidisers in cyaniding: new theory of solution of gold." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1913).
49. "New Data on atomic weights." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1913).
50. "Tetrabromodiphenoquinone." *Proc. Chem. Soc.* (1913).
51. "Quinonoid derivatives of dianisidine." *Report S.A. Assoc. for Adv. of Science* (1913).
52. "Indicators *re* acidity of mine waters." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1913).
53. "The nature of solutions of iodine in iodides." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1914).
54. "Indicators and true neutrality." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1914).
55. "Dust in Mine Air and causation of Miners' Phthisis." *Journ. Chem. Metall. & Mining Soc. of S. Africa* (1915).
56. "Further experiments on the minuteness of the dust in Miners' Phthisis." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1915).
57. "Loss of cyanide and the value of protective Alkali." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1915).
58. "Analysis of Niobium-Tantalum minerals." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1916).
59. "New test for Molybdenum." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1916).
60. "Formula for calculating humidity of mines." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1916).
61. "Nature of dust in silicotic lungs" (with Dr. W. W. Pitchford). *S.A.I.M.R Bulletin* (1916).
62. "New methods of determining dust in air" (with A. McA. Johnston). *Report of Miners' Phthisis Prevention Committee* (1916).
63. "Statistical enquiry into sizes of dust found in Silicotic lungs." *Report of Miners' Phthisis Prevention Committee* (1916).
64. "Errors and possible accuracy in Analyses." (Pres. Address). *Proc. S.A. Assoc. of Analyt. Chemists* (1916).
65. "The classification of Indicators, with the true reaction of nearly-neutral solutions." *S.A. Assoc. of Analyt. Chemists Pamphlet* (1916).
66. A rapid volumetric method for the analysis of Limestone." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1917).
67. "Volumetric analysis of Ammonium Salts with thymolphthalein." *Journ. Chem., Metall. & Mining Soc. of S. Africa* (1917).
68. "Colour and Chemical Constitution: spectra of 47 derivatives of phenolphthalein in Alkali and in Concentrated Sulphuric Acid." *Trans. Royal Soc. of S. Africa* (1917).
69. "Colour and Chemical Constitution (Part II): Mixed or unsymmetrical phthaleins." *Trans. Royal Soc. of S. Africa* (1917).
70. "Colour and Chemical Constitution (Part III): Orthopara-phthaleins." *Trans. Royal Soc. of S. Africa* (1917).
71. "Spectra of Chromium compounds (compared with Ruby and Emerald)." *Trans. Royal Soc. of S. Africa* (1917).
72. "Modern Alchemy and Transmutation and the periodic law." *Journ. S.A. Assoc. Analyt. Chemists* (1917).
73. "A new Analytical method of Copper." *Journ. S.A. Assoc. of Analyt. Chemists* (1917).
74. "Colour and Chemical Constitution (Part IV): Highly complex phthaleins." *Trans. Royal Soc. of S. Africa* (1918).
75. "Colour and Chemical Constitution (Part V): The yellow phthaleins." *Trans. Royal Soc. of S.A.* (1918).
76. "Colour and Chemical Constitution (Part VI): Ultraviolet spectra of phthaleins." *Trans. Royal Soc. of S. Africa* (1918).

77. "Colour and Chemical Constitution (Part VII); Spectra of Cobalt Nickel and Uranium Salts in solid state." *Trans. Royal Soc. of S. Africa* (1918).
78. "Colour and Chemical Constitution (Part VIII): Fluorescence and its laws. *Trans. Royal Soc. of S. Africa* (1918).
79. "Miners' Phthisis and defence of the Konimeter." In Blue-book under publication.
80. "A new type of Sundial or Solar Clock." *Report S.A. Assoc. for Adv. of Science* (1918).
81. "Rapid approximate method of Calculating Occultations.." *Report S.A. Assoc. for Adv. of Science* (1918).
82. "Errors in Analysis of Chrome ironstone, with a new process. *Journ. S.A. Assoc. of Analyt. Chemists* (1918).

Previous Recipients.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., V.M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.

1910. *Capetown.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Capetown.

1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Capetown.

1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, C.P.

1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.

1914. *Kimberley.*—Prof. Rudolph Marloth, M.A., Ph.D., Capetown.

1915. *Pretoria.*—Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria.

1916. *Maritzburg.*—Thomas Robertson Sim, F.L.S., F.R.H.S., formerly Conservator of Forests for Natal.

1917. *Stellenbosch.*—John Dow Fisher Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Professor of Zoology, South African College, Capetown.

1918. *Johannesburg.*—Robert Thorburn Ayton Innes, F.R.S.E., F.R.A.S., Union Astronomer, Johannesburg.

ASSOCIATION LIBRARY.

The following publications are regularly filed at the office of the Association, Cape of Good Hope Savings Bank Buildings, St. George's Street, Capetown.

General Science.

Royal Society of Edinburgh: Proceedings.
Royal Society of South Africa: Transactions.
Royal Society of South Australia: Memoirs.
Royal Society of South Australia: Transactions.
Royal Society of Victoria: Proceedings.
Royal Society of Canada: Proceedings and Transactions.
Royal Society of Tasmania: Papers and Proceedings.
Royal Society of Queensland: Proceedings.
Royal Dublin Society: Scientific Proceedings.
Royal Institution of Great Britain: Proceedings.
Royal Philosophical Society of Glasgow: Proceedings.
Royal Society of Arts: Journal.
Michigan Academy of Science: Reports.
Chicago Academy of Sciences:
  Bulletins.
  Special Publications.
Reale Academia dei Lincei, Rome: Atti.
Kungl. Svenska Vetenskapsakademien:
  Handlingar.
  Årsbok.
Koninklijke Akademie van Wetenschappen, Amsterdam:
  Proceedings of the Section of Sciences.
  Verhandelingen.
Real Academia de Ciencias de Madrid: Revista.
British Association for the Advancement of Science: Reports.
Australasian Association for the Advancement of Science: Reports.
American Association for the Advancement of Science: Proceedings.
Indian Association for the Cultivation of Science:
  Proceedings.
  Reports.
  Bulletins.
Società Italiàna por il progresso delle Scienze: Atti.
Association Française pour l'avancement des Sciences: Conférences.
Cambridge Philosophical Society:
  Transactions.
  Proceedings.
Manchester Literary and Philosophical Society:
  Memoirs and Proceedings.
American Philosophical Society: Proceedings.

University of California:
Bulletins.
Memoirs.
University of Virginia: Philosophical Society Bulletins.
Tôhoku Imperial University: Science Reports.
New York Academy of Sciences: Annals.
American Academy of Arts and Sciences: Proceedings.
Connecticut Academy of Arts and Sciences: Transactions.
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PRESIDENT'S ADDRESS.

ADDRESS

BY

THE REVEREND WILLIAM FLINT, D.D.,

PRESIDENT.

RACE-CONSCIOUSNESS AND THE SCIENTIFIC SPIRIT.

That the scientific spirit can with advantage be applied to the consideration of problems other than those which are merely physical is evidenced by the development of research investigation in matters pertaining to race and nationality which grow out of ideas rather than physical conditions. The study of race questions necessitates making due allowance for such natural facts as are connected with the human organism, its history and its habitat, but psychological and ethical factors are found to obtrude themselves so often that no adequate account can be given of race-consciousness without allowing fully for the parts played by these. The facts concerning man cannot be so isolated and submitted to the processes of the physical method as to enable us to state "This is," "That is not," and to predict with

certainty that given combinations will produce unvarying results. The social reformer, the Parliamentarian, the diplomat have no laboratories in which they can produce results akin to those of the synthetic chemist, but they can emulate his spirit. In discussing questions pertaining to race we are not dealing only with matter, even sentient matter. There is what is termed human nature involved, and it is impossible to proceed far in any direction without the physical enquiry merging into a metaphysical discussion. A new process of separating and refining gold may be so demonstrated as almost to compel its acceptance throughout the world where similar conditions exist, but there is no exact science of human nature which will enable us to invent, discover, or apply tests which will be invariable in their operation, and so enable us to bring about improvement in results which we are seeking. Still the questions to which science may assist in finding an answer are numerous, and the aid of the scientific spirit especially should prove of very real value. If it be asked wherein the advantage of that spirit consists, let the answer be found in the work of a Lister, a Pasteur, a Curie, an Edison. These, whose discoveries and applications of knowledge are lauded by the world, sought for truth in facts; they sought it fearlessly, they applied it honestly, and they did not expect satisfactory results if they neglected, ignored, or defied the facts which they verified. The problems in the field of human nature are of a different character to theirs, but who shall say that they are not more readily soluble than we have found them hitherto if approached in the same spirit? But that spirit must include an unwavering desire and determination to know, followed by an unfaltering courage to apply the knowledge gained. At the back of the scientific spirit there is always the definite assurance that Nature cannot be fooled. The experiment which is not wholly honest produces no reliable result. Any earnest study of man in this spirit will reveal some facts relating to his being which can be definitely verified, and these being established make a not altogether useless contribution to the practical study of questions rising out of race interests, race prejudices, and concurrent matters. On the other hand, a merely physical investigation does not explain race-consciousness, or suggest a remedy for the problems which that consciousness creates. When physical science has done its best there will still be found that in human nature which does not react to any physical test. Yet when it is stated that the physicist deals with facts and the metaphysician with words the distinction is unworkable. Words are the symbols of facts, and things, and their properties; and race-consciousness is a property of human nature for which the merely physical does not adequately account. Science has been defined as organized knowledge, and the first step towards the solution of the problems before us is the knowledge of what race-consciousness really is.

I. The first outstanding fact which should be noted concerning the human race is its unity.

A typical man of any race regarded from any point of view —physical, mental, moral—will stand forth as having characteristics which are representative of every normal member of the human race.

(*a*) Take his organic form. Morphologically the development of the human of any race as a living organism speaks of unity.

(*b*) The same is true when he is viewed physiologically. A consideration of the processes and functions of the parts of the human organism testify to solidarity.

This, if pressed, may perhaps tend to lead a little far for the comfort of some who are sensitive in regard to their kinship with certain sections of the animal creation, but after all we are animals. Still, we are animals with a difference. An elephant is not a giraffe, and a man is not an ape, however much he may resemble one. The implications of the unity of man do not include his complete unity with the highest order of the animal creation outside of his own, because they include more than that. There are no transactions yet produced by a Society of Apes for the Advancement of Science, but the lowliest form of man yet discovered may be conceived of as a rudimentary scientist. He gives evidence of studying the markings, habits, and haunts of the animals he kills, distinguishing those he likes best, communicating his knowledge to his fellows, and working in concert with them to secure what he requires, or to save his food-stocks from being killed off too rapidly, or even killing other beasts which prey upon them; improving and adapting from time to time the implements with which he does this, and leaving records of his methods in the rich stores of his kitchen middens and in his graphic rock-paintings: all of which is a rudimentary association for the advancement of science. There is pure science in the knowledge of fact, and applied science in the wisdom of action.

It is, however, not a principal part of this enquiry to enlarge on the essential unity of the human race, or to dwell upon the points in which it is differentiated from the rest of the animal creation. Through the ages various and subtle processes have been at work to produce new expressions of the form divine, and at the same time powerful counteracting influences have been labouring to bring about reversion to type. There are suggestive theories regarding the origin of, and the purpose in, all this, some purely materialistic and others giving large place to the work of mind and spirit. They can barely be mentioned here—

A fire, a mist, and a planet,
  A crystal, and a cell,
A shellfish and a saurian,
  And a cave where the cave-men dwell.
Then a sense of law and beauty,
  And a face turned from the clod,
Some call it "Evolution,"
  And others call it "God."

An older literature begins its story—"In the beginning God created the heaven and the earth." "And God said, Let us make man in our image, after our likeness."

What has to be borne in mind is that behind all race-consciousness is this unity. That is an essential factor in its content, and our observations, conclusions, and actions, if animated by the scientific spirit, must never lose sight of its implications.

Anomalous as it may seem, it is what all men have in common because of the solidarity of the race which produces the problems arising out of the diversity which time and circumstances have brought about. The primary reason why the races struggle and fight with each other is not because they differ, but because their fundamental similarity and oneness will not admit of one being dominant over the other.

II. If the unity of the race stands out with such distinctness no less clearly is its diversity apparent.

It is in our association with this latter we find the difficulties of race-consciousness first making their presence felt, and under two distinct sets of circumstances—(i) as between different sections of the European peoples, (ii) as between white and coloured races.

(i) The consciousness of diversity as between different sections of the European peoples.

The examination of that has not proceeded far before it is found necessary to distinguish between what is the result of heredity and what the consequence of environment, when it will be seen that what may have originated in race-consciousness in earlier times is now little more than national consciousness in many instances. The proclivities which have come along the line of physical descent are not easy to distinguish from mental proclivities more recently received. A child receives from environment certain mental suggestions which seem to be of nature, but are not necessarily so, as is witnessed by the ideas of a similar child in another environment. We have not forgotten W. S. Gilbert's apt hint of how prejudices may, under certain conditions, become stereotyped in families—

I often think it's comical
  How Nature does contrive
That every boy and every gal,
  That's born into this world alive,
Is either a little Liberal,
  Or else a little Conservative.

In many a well-known English family in a past generation that seemed quite apparent, and yet, of course, it was not true. Environment and mental suggestion were the factors at work. In the hundred and one little antipathies which exist between the individuals of different races and nationalities this much seems evident: that as between the race-consciousness, of which colour is the outward and visible sign, and that as between the white peoples themselves, there is certainly a difference of high degree or even of nature. Dealing with the latter, it suffices to state

that no very clear line of distinction can be drawn between Race, Nationality, or even Statehood, which will alone account for the differences and prejudices which exist between the several peoples of Europe. There are questions of language, territory, natural or artificial boundaries, hereditary rulership, and many other factors all involved to such an extent that what is at first deemed to be race-consciousness very frequently proves on a closer examination to be something far more recent and artificial than that.

The historical development of a people producing national identity is conditioned not only by natural heredity and environment, but also by ideas superimposed upon these, and the growth and influence of the last-named are extremely subtle. As exerting a natural force geography accounts for much that is peculiar to certain peoples, though it is a long story to trace, for instance, the growth of the characteristics of an island people through the ideas growing out of fishing and seafaring habits which have hardened into propensities. Moreover, it has to be remembered that there are forces which work in an opposite direction with an equally powerful effect, as witness the case of the Jews by the force of ideas preserving a race intact through all the years in defiance of geography.

Ideas come from many sources, such as the habits and occupations of the people. The history of a country like Great Britain reveals how economic conditions bring about easily recognized changes in physical and mental type, having many advantages in transmitted capacity and adaptability for the particular difficulties involved in the occupations concerned, thus in a particular sphere producing a very definite form of consciousness. As to its nature, it may be noted that the content of the consciousness will often be found marked by ideas which have a narrowing effect upon life as a whole. But let new racial elements be introduced, or new industries which require a readjustment of outward relationships and an enlargement of the circle, the very friction and criticism introduced by this will stimulate a further life. A particular nationality like that of the English has received very marked and definite enrichment from those who have been welcomed from other lands through the policy of the open door, but whose numbers at any one time have not been so great as to prevent them from being absorbed into the body politic. Therein is a lesson for young nations, anxious to broaden their life while retaining their identity. A distributed settlement may be inconvenient at first for the settlers, but if they come from a land far behind in civilization it is better for them and the land of their adoption that they should not constitute coteries of separate and possibly disaffected nationalities exercising a narrowing influence. Both their descendants and the country and its people gain by absorption, a narrowing influence being thereby transformed into a broadening and stimulating element. Of this there are numerous illustrations in Europe.

Distinct groups of people bear the marks of successive influences from the various causes named. So it may be affirmed that national consciousness, as found in Europe, reveals the fact that, while there are strong race traits still present, race and nationality among the European peoples can rarely be regarded as identical. The most diverse ethnological elements are inextricably blended. Doubtless in certain sections of the continent there are craniological peculiarities which testify of Eastern origin, and elsewhere distinctions in colouring, which tell of journeyings from the south, but no nationality is so free from exceptions to either of these as to make race and nationality one. Sweeping generalizations regarding populations may serve a political purpose, but they fail in the exactitude which science demands. Whole sections of population in some areas have a consciousness much more affected by religion than race, while in many instances the consciousness is much more political than racial, having been created by the vertical divisions set up by astute and self-seeking rulers. An illustration of this is seen in the carrying out of such maxims as those left by Frederick the Great for the guidance of his successors.

If possible, the powers of Europe should be made envious against one another, in order to give occasion for a *coup* when the opportunity arises.

I understand by the word "Policy" that one must make it his study to deceive others.

Form alliances only in order to sow animosity.

The history of Germany since Frederick reveals how in a few generations a definite form of national consciousness may be created in a people by a conspiracy or combination of the rulers and teachers of the nation to make a certain set of ideas dominant.

Of what heterogeneous elements a European nation is composed has been graphically set forth by Henri Fabre, who of his own France writes:

Long ago, it used to attract the sea-roving Phœnicians, the peace-loving Greeks, who brought us the alphabet, the vine and the olive-tree; the Romans, those harsh rulers, who handed down to us barbarities very difficult to eradicate. Swooping on this rich prey came the Cymri, the Teutons, the Vandals, the Goths, the Huns, the Burgundians, the Suevi, the Alani, the Franks, the Saracens, hordes driven hither by every wind that blows. And all this heterogeneous mixture was melted down and absorbed in the Gallic nation.

When an attempt is being made to set the European world in order at the present time it is not a little strange that two conflicting principles should be seen at work in the present peace-efforts—the self-determination of small nationalities, which is in danger of becoming a fresh emphasis of the vertical divisions between the several peoples; and the working out of a League of Nations, which can only be effective through the development and utilization of the lateral interests of the people as a whole.

The failure of the form of civilization which has hitherto

been dominant in Europe, and which has culminated in the great war, is self-evident. What is not always as clearly recognized is, that it is, and must always be, the natural effect of excessive and self-contained national consciousness, however brought about, to produce conditions which make war inevitable, unless checked by counteracting forces. In the case of a small people an emphasized nationalism may turn in the direction of exclusiveness which entails atrophy, but in the case of a great nation, alert, ambitious, and progressive, it is much more likely to produce a type of imperialism, which in its turn will be productive of all sorts of antagonisms. Excessive nationalism may produce intensive culture, good and progressive for a time, but let the excess develop into exclusiveness, and the effects can only be detrimental. Its hope of the future lies in the reception and assimilation of new immigrants and new ideas, and a true understanding of the relation of the part of humanity to the whole. The hope for the great nation is that its consciousness shall be made to tend in the direction of federation and co-operation. Signs are not wanting that there is a strong tendency in that direction to-day, and that what I have termed the lateral interests of humanity may be more and more substituted for the vertical divisions. Such a spirit is to the forefront in the various pleas which are being put forward for the recognition and emphasis of the universal character of such human interests as are to be found in labour, the conditions of industry, food production, the health of the people, education, religion, literature, social amenities and civilization in general. All of which means the development of an international consciousness, whch after all points in the right direction, if the solidarity be accepted. This at least must be conceded, that biologically there is little justification of the limitation of outlook and interest so often present in the artificial relationships which have hitherto existed between different peoples.

This need not impinge upon a natural and commendable love of country. True patriotism is a noble quality, and when kept free from selfishness and greed is productive of the loftiest ideals and the divinest sacrifices. It engenders a healthful spirit of emulation, and like the life-blood coursing through the human body, reaches the remotest member of the nation in the most distant land, and warms in him the consciousness of having a share in a national heritage, and his own little measure of responsibility in upholding the best of its traditions. But the perils of excessive patriotism are many and great. To unduly differentiate between our own nationality and that of other people tends to the fault of giving an unnatural stress to the word "foreign," and to the development of excessive means for self-protection, which may easily become militarism. It may be that the respect begotten by fear has its value, but it can never be the highest kind of respect, and the defence of States against each other must rely more and more in the future on the development of lateral interests, and that consciousness begotten by the international

spirit, which can only be attained by an honest regard for the rights and feelings of others.

The egoism of states, of races, has its good side, as in the liberty-loving consciousness of the British and American, but such egoism is always in peril of being manifested, under provocation, in ways which, while giving freedom in one direction, may take it away in another.

It must ever be a defective patriotism from the standpoint of the scientific spirit which includes only the love of its own nation as worth consideration. Science demands the recognition of all the facts, and one very real fact must always be the patriotism of other people, patriotism as a lateral interest. A patriotism which is merely French, or German, or British, or even South African, carries its own retribution, narrowing its own outlook and creating potential foes.

To lessen the evils of national consciousness may not be an easy task, but it is of some assistance to remember that ideas and prejudices, however deeply rooted, do not necessarily remain stable, and one hope of the human race tending to international amity is that the race permeated with the idea of its own unity shall strive after a larger unity of aim in the solution of the great social problems of humanity, which, after all, concern the people more closely than mere boundaries, or dynasties, or even forms of government.

In the past, too often, national consciousness has unfortunately become identified with national selfishness, and though the words of Stuckenberg may be strong, they are, nevertheless, only too true: "An unprejudiced reading of history establishes one thing beyond all controversy: their power and magnitude and selfishness have often made the States, in their treatment of each other, the worst pirates, the most unscrupulous robbers, the most cruel oppressors, and the most brutal assassins." The desire on the part of one nation to advance its own fancied interests regardless of the interests of others, or the necessity of defending the interests of the nation against the attacks of other nations with specially exaggerated ideas of personal interest, has produced disaster.

With the interests of despotic dynasties largely eliminated a reduction of the war-making elements in the world has now taken place, and it is for humanity to ensure that they are succeeded, not by other elements pointing in the same direction, but by such peace-securing elements as will stabilise the peoples. Again, this reminds us that attention to the lateral, human interests of the peoples in all communities must more and more engross our attention if security is to be ensured.

An apt illustration of the contrast produced by attention to such interests, as distinguished from vertical divisions of different peoples, is seen in the respective relations of Scotland and Ireland to England at the present time. In the case of Scotland the truth was long since discerned that the future progress of its people was to be found along the line of interests belong-

ing to the people as men and women, and not merely as Scottish folk, with the result that Scotland has contributed to, and shared in, the advance which the past century has brought to the British Empire to an extent far beyond her proportionate numbers; while Ireland, with her eye on the vertical divisions, has been brought into her present unhappy position.

So it may be concluded that national consciousness, as developed by the chief and ruling place being given to barriers, dividing lines, and other vertical divisions of separation, has a tendency to over-assert its own special characteristics, to endeavour to bring others into conformity thereto, and in doing so to make the interests of others continually subservient; whereas a candid recognition of what is distinctive and valuable in others, and a cultivation of the spirit of tolerance, reveals how the lateral interests of humanity are those which are most deeply seated and of abiding importance. It is this which the scientific spirit enforces upon our attention in bidding us take into account all the facts, and keep them before us all the time. The universal is substituted for the particular, and though every nation may rightly cherish its own ideals, it discerns the fact that in the spread of these through peaceful means its own and the world's highest interests are to be found.

These are some of the factors which, neglected in the past, or thrust into the background, have produced jealousy and strife, militarism and war, the devastation and death of the past five years.

If any legacy of good can come of these experiences, it is that the human race shall come to realise its own solidarity beneath all its surface diversities, and in the fundamental laws of unity find the prospect of abiding peace.

(ii) In approaching the subject of what is more strictly Race-Consciousness, we find ourselves facing a much more difficult and delicate problem.

The qualities demanded in its investigation are largely ethical. They include Honesty, Candour, Tolerance, a willingness to face the whole truth. A scientist destitute of certain of these qualities discredits himself and is doomed to failure, and a deliberate determination to ignore a whole series of facts brought to his notice would be a most unscientific procedure. Yet in reference to race questions solutions are often sought with scarcely any reference to the ruling factors in the situation.

That a very real problem exists in the race-consciousness of the white and coloured peoples is evident, sometimes painfully evident, sometimes dangerously so, and nothing is to be gained by under-estimating its deep-seated nature and the gravity of its issues.

That an immediate solution of it is ready to hand, even for the most earnest seeker, no wise man will affirm. That the right road to travel is the road of Truth and Fairness every analogy of science declares.

Lest what follows should seem to be an advocacy directed

to one side only, it may be stated that the difficulties in upholding the attainments and pursuing the ideals of the white race in face of an aggressive movement on the part of the coloured races are fully recognized as being well known, and not specially needing elucidation. The neglected factors on the other side do need a fresh and temperate statement. In what the race-problem consists it is not easy to determine with exactness. Professor Royce, of Harvard, in "Race Questions and Prejudices," observes:—

> Scientifically viewed, these problems of ours turn out to be not so much problems caused by anything which is essential to the existence or to the nature of the races of the men themselves. Our so-called race problems are merely caused by our antipathies.

But these antipathies must not be belittled. They are not in the category of "merely." They have effects which indicate that whatever may have been their origin they have become over wide areas second nature, and are so deeply-rooted that their destruction or reversal is likely to be a very slow process indeed, and meanwhile may involve much suffering and danger. That the prejudice is in many instances artificially exaggerated and unreasoning does not lessen the peril to which society is exposed. That it is not altogether natural is evidenced by the fact that whole classes of people reared under widely separated conditions do not feel the prejudice to anything like an equal extent, such as would probably have been the case had both the groups been in equally close contact with the opposing race. The consciousness of difference is there, perhaps innate, but only develops into activity as prejudice because of the local friction between the race groups. How powerful it may become, and how artificial it sometimes is, the facts reveal. An instance of this may be related from personal experience. It was on the occasion of a coach journey in the Transvaal nearly 30 years ago, when a man, who was anxious for a box seat next the coloured driver, resented the presence of a coloured passenger on the other side of him, though very much better dressed, and in every way more presentable than the driver. What his motive was makes an interesting study, but pride, prejudice, and some other kindred qualities must surely have interfered with his logic. An absence of intellectual honesty is even suggested.

Still, it renders no real service to underestimate difficulties, nor need we take refuge in discussions as to the relative purity of races. There is a broad band of racial purity on each side, though it is not necessary to deny the existence of the varying colour blend which lies between.

To what must we attribute the prejudice which arises out of the race-consciousness of the white band? For want of a better term it may be called a sense of superiority, but in affirming that it may be asked whether we are quite sure that such superiority is in every instance a foregone conclusion? If such is our point of view, it may be asked whether we mean inherent or acquired superiority? The scientific spirit bids us ascertain

the point of view of other races involved. It is not unlikely that such investigation will reveal the fact that Chinese, Japanese, Indian will not readily admit the claim, whatever may be acknowledged by the cannibal aborigine. As a matter of fact, the Chinese are often deeply conscious of an absence of certain Eastern virtues from our Western social system. It is at least a question open to argument in some phases, and we must not lose sight of the affirmation that the infusion of Eastern and even of African blood in European veins is one predisposing cause of the development which has resulted in our present civilization.

Too much is sometimes made of a phrase like that of Kipling's concerning East and West. There is a sense in which Occident and Orient may never meet, but when Kipling is read aright they are found capable of travelling in the same direction, and the peril and difference are not so great as when an unthinking philosophy makes them eternally different from each other. His ballad really teaches that the elementary virtues are the same the world over, and the balance is often very delicate as between the claim of these and the distaste of other factors. His picture of the Brothers-in-Blood has surely a counterpart in brothers whose blood is unshed, which awaits discovery and exploitation.

Yet whatever may be argued, there are certainly elements in our white civilization which we prefer to any other, and which, because of their intrinsic worth, we do well to guard; but the question of relative superiority while affecting our relations with Eastern peoples in one degree, to a much greater extent enters into the relations between European and Bantu or Negro peoples. The sense of superiority is often accompanied by a feeling of repulsion, and seems to be so overwhelming as to admit of no sort of moral control, and proceeds to ignore wellnigh every claim which the other race may have to treatment based on fairness, while the innate consciousness of that race that, though at present debased by its history and environment, it has the capacity to rise and develop is treated as a presumptuous dream.

The clashing forces are in operation, and if science may not be able to elaborate any system of final adjustment of the differences, it does demand the recognition of the known facts of the situation, and the application of the laws of the case so far as they can be ascertained.

The facts present themselves in various phases in different parts of the world—(*a*) in Central Africa, where at the earlier stages of contact no question of social equality is presented and no democratic political rights are considered; (*b*) in South Africa, where the social and political advancement of the native peoples is pressing the difficulties forward with ever-increasing urgency; (*c*) in the Southern United States, where the two races, in more nearly equal numbers than anywhere else, and with theoretical equality as a political basis, have found at present no solution satisfactory to either side; (*d*) in Spanish South America, where we have such a near approach to a fusion of

the races in certain areas as to make it difficult to draw a colour line.

When the condition of the various communities is considered, the conclusion is easily reached that a monochrome race and civilization would be universally desired if such were possible. That cannot be, and the courses open to us await consideration. These are—

(*a*) The Policy of Segregation which is only partially possible, and which offers no real solution if the resoective races are to live in the same country. It is a theory the real benefits of which can never be realized in practice as long as human nature remains what it is and makes its present demands.

(*b*) The Policy of Haphazard, if that is not a contradiction in terms; the continuance of a state of flux, controlled by passing impulses of feeling, personal and often irresponsible, and selfish interests tempered by efforts for betterment, which must be continually frustrated or reduced in value by insincerity of application.

(*c*) The Policy of Antagonism, a state of more or less open conflict, in which each race seeks its own advancement regardless of the feelings of the other, and which can only result in a growing unrest with all the possibilities of disaster, the end of which it is difficult to foresee.

(*d*) The Policy of Miscegenation; a deliberate lowering of social ideals to make one race, which is unthinkable, although we are compelled to recognize that it is just here that the most powerful influences are always at work in a bi-racial community to make a breach in the colour line. No discovery of science and no effort of the lawmaker has produced any effective barrier in the way of this where the two peoples live together in the same country. It is one of the facts which have to be accepted, part of the price which has to be paid for the exploitation of countries which once were given over to another race, unless another conception of the sanctity of race can be substituted by individuals for that which at present exists. Deprecate it as we may, there are four distinct forces at work to break down the colour line. There is first Wealth, which, where the colour line is most attenuated, is a contributing factor in not a few mixed marriages. How it operates is too well known to need comment. There is secondly Poverty, which brings the races together in such a way as to lead inevitably to marriage, and in which the parties most concerned are seemingly quite content to accept the conditions in which they find themselves, notwithstanding the penalties which Society often inflicts. There is thirdly Affection, the genuineness of which there is no reason to doubt—that uncontrollable and mighty force which ere now has brought dynasties into conflict and devastated the fairest of lands. Then, fourthly, there is the old and yet ever new manifestation of natural instinct, which, unbridled and often blind, contributes its quota to the number of those who dwell on the

borderland of racial purity. To these may be added, perhaps, genius, character, some outstanding quality on the part of man or woman, on the one side or the other, which tempts to a leap over the racial barrier.

It is evident that in neither of the policies indicated can we find a permanent or satisfactory solution of our problem, or even a temporary method of treatment which can be contemplated with equanimity.

(*e*) There remains what Science points out as the only true method of dealing with such a question as this: the clear conception of the facts involved in race consciousness, the candid recognition of the basal right of all races and every human being to live and advance, which must be followed by such readjustments of social and political relationships as may be found desirable and practicable. It is here we find great fundamental factors neglected, and a trailing of false scents across the line which confuses the main issue.

The mental hysteria which has been manifested here and there in South Africa and in the Southern States of America in pogrom-like attacks on natives is at once lowering to our conception of the white race, and an intensifying of the complications already involved in our problem. We dare not contemplate the idea of turning South Africa into a permanently armed camp as between white and coloured races, and the cost of tolerance and helpfulness on the part of the white man towards the native may as well be faced honestly and fearlessly. Otherwise we force the matter into the hands of the agitator, whose opportunities will increase and not lessen as the years pass, unless the nation is aroused to its responsibilities.

Accepting the present superiority of the white race and its civilisation, we cannot escape the obligations and responsibilities of that superiority. Though scientific experiment and theory may not directly concern character, yet we cannot, in adopting a method which asks for all the facts, explain race consciousness and either justify or condemn its expression, or attempt to improve its outward relations without recognizing the ethical element.

Starting on the lower ground, science allots to objects and organisms the functions of which they are capable, and in utilizing them, suggests the aid needed in performing such functional operations to the best advantage.

The coloured races are no longer in the dark concerning their own potentialities, and the social, economic and political rights which are enshrined therein. Chinese, Japanese, and Indian on the higher platform, and African on the lower, are advancing with strides, which in some instances are assuming gigantic proportions, and, as one has tersely put it, "The race must come to terms with the races."

We cannot, if the dictates of science are to be obeyed, place the native life, with which we are in contact, and our treatment of it, on a lower plane than that of our growing crops and

domestic animals, yet that is precisely what those are doing who reject all attempts at education, social advancement, and any other effort towards the betterment of conditions, save such as subserve the purpose of producing a labourer at the minimum of cost, and with the least possibility of making him a competitor in any other department of life.

It is essential that due regard be paid to the race-consciousness of a people who recognize a sense of lack in their present degraded condition, who feel the need of education to supply what is wanting, and who are moved by a desire, increased by a knowledge of what some have already accomplished, to attain to a higher standard of life and service in the community. That everything which is desired cannot be granted or attained all at once is no reason whatever why all that can be done should not be done. Civilization in a hurry would necessarily produce pernicious results, but to block it almost completely by unfair and unreasonable repression is to sit on the safety-valve, and the community which does that of set purpose, or even through carelessness, must accept the consequences. Citizenship cannot in these days be permanently withheld from any section of the community which shews its fitness for it without endangering the peace and safety of the body politic.

The duty before us seems to lie in this direction—

(*a*) To conserve the universal interests, as far as may be, which the consciousness of both races conceives to be of permanent value.

(*b*) To supply the lack which either expression of race-consciousness fails to recognize, which can only be done by a process of mutual education through intellectual intercourse.

(*c*) To so advance the interests of the community as a whole that security and progress for the future shall be ensured.

In regard to these propositions it is a commonplace of all race intercourse that the relationships must be characterised by justice, not only in matters pertaining to law and its administration, but in due consideration for each other's point of view, in opportunity for advance freely granted, and in the provision of such means as are essential thereto. Our native people must learn that claims and aims must be clearly and temperately advanced, and that the value of character behind them is of prime importance. They should be encouraged in this direction by due recognition of the nature and spirit of such efforts for advancement, as against the engineering of crises which call for the use of force and delay progress. They must have clearly revealed to them the sources from which our greatness has been derived and taught the value of them.

In this respect no little assistance is afforded by a grasp of the mutuality of the interests involved. This is evident, sometimes distressingly so, in such a matter as Health. A Southern Officer of Health affirms of the negro: "If he is tainted with disease you will suffer." What is true of physical health

is equally so in regard to Morality the same officer affirms in adding: "If the negro develops criminal tendencies you will be affected." The nation as a whole loses by every physical degenerate which it produces, and by every criminal which it helps to create, and national efficiency has its standard lowered throughout in proportion to the extent to which its individuals do work inferior in quantity and quality to that of which they are capable.

Herbert Spencer's dictum is worth pondering in this relationship: "No one can be perfectly free till all are free; no one can be perfectly moral till all are moral; no one can be perfectly happy till all are happy."

A system of life which persistently ignores the claim and potentiality of the moral consciousness in the working out of these problems is self-condemned. "Any system of ethics must aim to develop character; it must establish a standard of good and evil; it must judge actions according to this standard and provide an inner check, which will restrain the will of the individual," is a sentiment recently uttered, which has its application here.

Shelley sings of

> . . . . man
> Equal, unclassed, tribeless, and nationless,

but that can scarcely be in this every-day world. We have our race-consciousness, our differences of temperament and even of ideal, but we need not exaggerate these. Carlyle once drew a cynical distinction between the respective attitudes of the North and South of the United States towards the black population in the following way:

> The South said to the black, "You are slaves, God bless you!"
> The North said to the black, "You are free, God damn you!"

We need not follow either example. This we must recognise, however: every race has a right to existence; every race has a right to the best of which it is capable of becoming; every man has the responsibility of not hindering other races in their struggle for the best; every race which seeks the highest for itself will be foremost in helping other races to attain their best, for only in so doing can they reach their own highest.

Race growth must be slow, but there is no reason why it should not be real growth. To put the practical issue, there are four directions in which native aspiration is revealing itself which seem not unreasonable—

(*a*) Fair wages according to the nature of the work done, and the right to the necessities of advancing social life.

(*b*) Better housing, with special reference to town residents.

(*c*) Educational facilities.

(*d*) Political representation.

With increasing capacity for better classes of work better wages must inevitably come. The housing of natives in and on the outskirts of our towns is a disgrace for which terms of

condemnation can scarcely be too strong. Facilities for better and wider education in letters, in agriculture and industry, are being granted, but there is much leeway to make up. And the devising of an adequate and progressive system of political representation should not be beyond the power of a community like ours.

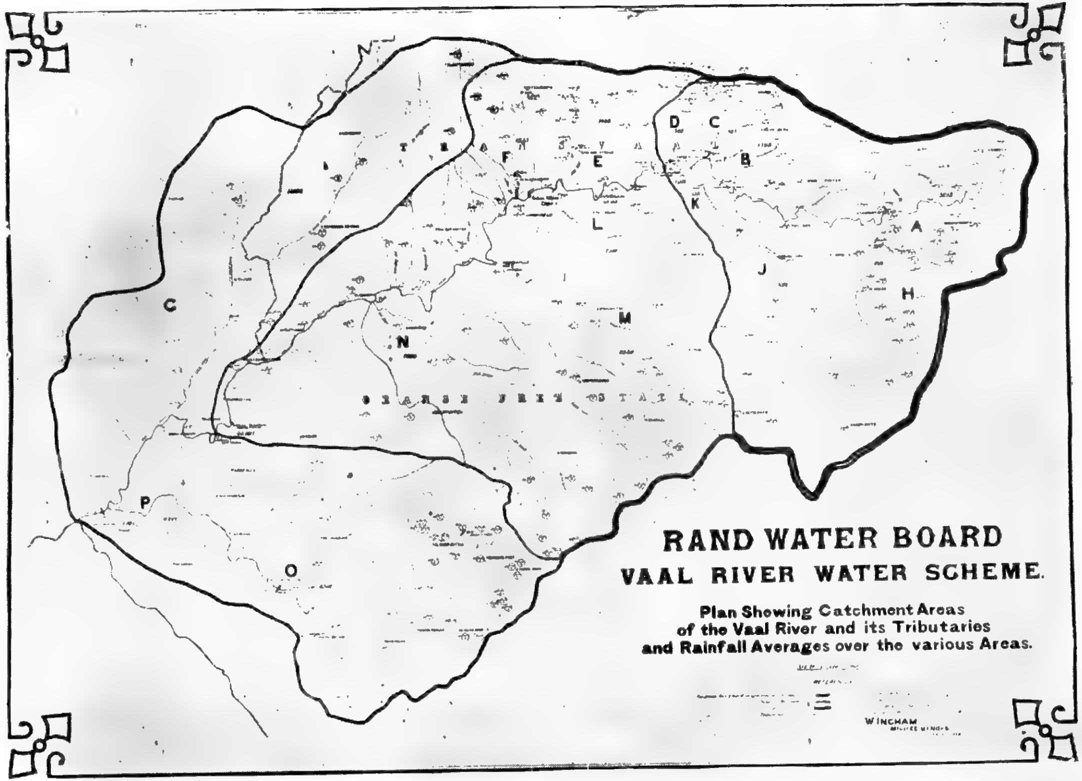
Referring to the larger aspects of race difference, Sir Douglas Haig has recently observed:

> These and other problems which must, unsolved, give rise to mighty wars are capable of solution by giving to all races, however insignificant, what we proudly regard as British freedom and justice, and thereby, in the course of many years, levelling them up to our own standard.

Perhaps the first practical difficulty in developing these aspirations arising out of native consciousness is the financial one. Money! Yes, it will cost money. So it does to keep out East Coast fever; but Science says, "Dip!" and the money has to be found. It costs money to get better crops; but Science says, "Phosphates," and they have to be obtained from somewhere. It costs money to improve the industrial output; but Science says the old machinery is wasted power, and Economics comes along and scraps it. Is it necessary to point out the analogy? Vested interests say, "It will cost us much in the way of social prestige, return for our labour, and in the profits on our capital"; but Science declares by every analogy of natural law, and by each disclosure of experiment, that if the Best will not improve the Worst, then the Worst will drag down the Best. Social questions which involve money do not, after all, take long to right themselves by natural processes of readjustment.

Sir William Ramsay, whose word should not be without weight in these circles, observes that, "The test of civilization is prevision; care to look forward, to provide for to-morrow; the morrow of the race as well as the morrow of the individual; and he who looks furthest ahead is best able to cope with Nature and to conquer her."

Our Geography defies our puny efforts to destroy it; we are here together for better or for worse. Our History refuses to be blotted out; we came here and must fulfil the responsibilities of being here. Our Science discloses the inexorableness of Nature's laws and bids us obey them. Our Consciousness as men, built on the solidarity of the race, though manifested in great diversity, bids us be true to our higher instincts; be faithful to the best in the best; join hands for the destruction of the worst in the worst; and aid the rise of all who seek to climb the eternal heights.



W. Ingham.—The Vaal River and its Possibilities

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President of the Section:—W. Ingham, M.I.C.E., M.I.Mech.E.

MONDAY, JULY 7.

The President delivered the following address:

THE VAAL RIVER AND ITS POSSIBILITIES.

The Vaal River rises about 15 miles north of Ermelo, and joins the Orange River at a point about 8 miles below Douglas and 112 miles below Kimberley. The river is wholly within the Transvaal until it reaches the junction of the Klip River (O.F.S.), about 22 miles below Standerton, but from that point the right bank is within the Transvaal and the left bank within the Orange Free State until the river enters Cape Colony at a point about 8 miles upstream of Fourteen Streams. The total fall of the Vaal River from Beginderlyn Road Bridge, which is about 80 miles above Standerton, to the junction with the Orange River, is about 2,000 feet, while the bed is from 60 to 100 feet wide above Standerton, and increases gradually to about 800 feet at the junction below Douglas. The length of the river from the Beginderlyn Road Bridge to its junction with the Orange River is about 805 miles.

The highest point of the catchment area is in the Drakensberg range, in the neighbourhood of Mont-aux-Sources, at an elevation of about 11,000 feet above sea-level.

The bed of the river is composed of a number of large pools, with a series of falls between the pools. As the falls usually occur where there is hard material or rock, engineers always examine such places for dam sites.

Some of the pools are several miles in length and 20 feet deep, and the depth of the river to bank level ranges from 15 to 40 feet. The total area of the catchment up to its junction with the Orange River is 73,747 square miles, and the area of the principal tributaries is given in Table "A."

The flow of the river varies considerably, and apart from the waterfalls, the velocity ranges from nil when the river is dry to about 12 feet per second during floods in the neighbourhood of Vereeniging, where careful observations have been made. The maximum flood discharge during the last 40 years at the site of

the Rand Water Board barrage was 183,000 cusecs on November 23rd, 1917, as compared with 172,000 cusecs in 1894, although the discharge at the Vereeniging Railway Bridge was higher in 1894 than it was in 1917. This is accounted for by a very heavy local fall of rain in 1917 on the 800 square mile catchment between the bridge and the barrage.

The fall of the river between certain points is given in Table G, and is also shown on the longitudinal section of the Vaal River from Beginderlyn Road Bridge to its junction with the Orange River. (See Plate 4.)

The largest portion of the catchment area is grazing land, and only a comparatively small area is planted with trees. The chief crops grown on the catchment area are maize, lucerne, barley and wheat, the first-named being by far the largest crop. Cattle do well on the grazing lands, but have in many cases to be removed to good winter farms in the hills for three or four months during each year owing to the dearth of good succulent grass on the farms adjoining the river during the dry season.

Several kinds of fish are found in the Vaal River, the most common being silver, yellow and mud fish and barbel, while carp is common in the Rand reservoirs and trout is found in some of the clear-water tributary streams.

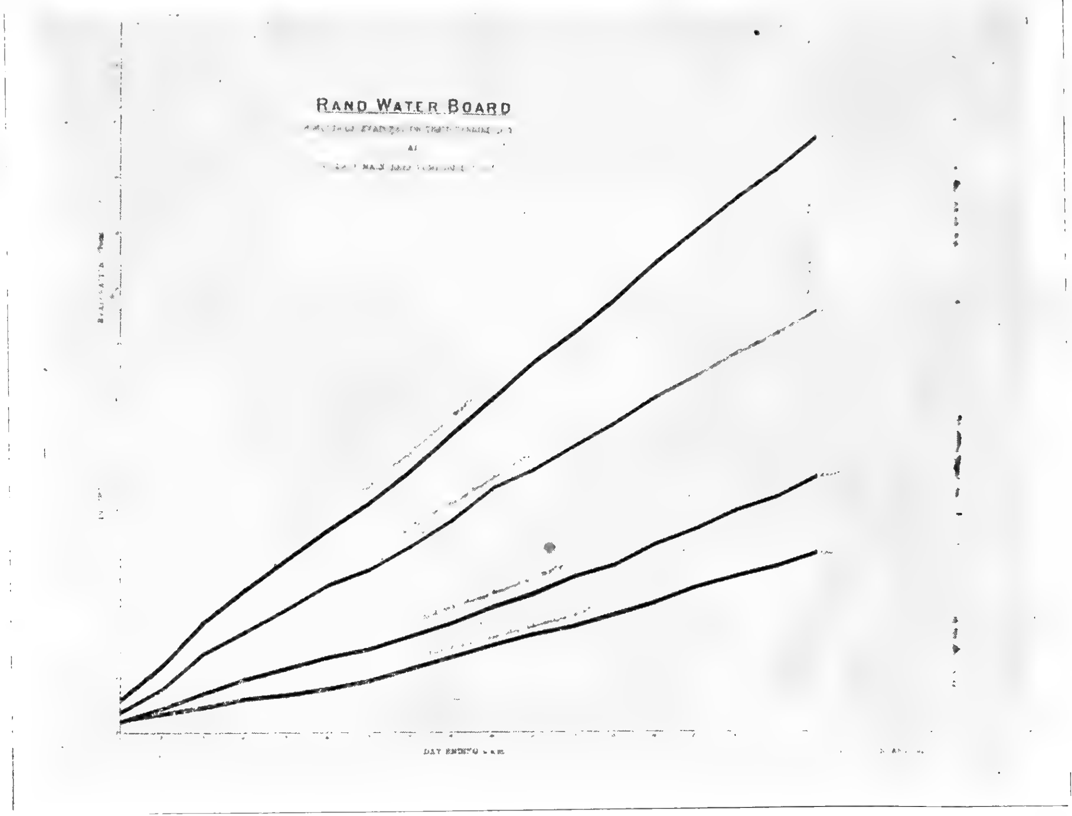
The catchment area of the Vaal is rich in minerals, gold, diamonds, coal, iron ore, lead and tin being the most common. Salt is also found in several districts, and a good revenue is derived from it. The Transvaal alone supplies nearly 40 per cent. of the world's gold output, and the coal output is over five million tons per annum, and is gradually increasing owing to the expansion of the export trade.

The geological formations consist of the following: About two-thirds of the Vaal River catchment area is covered by the Ecca Series and Dwyka conglomerate of the Karoo system. This area is chiefly on the Orange Free State side of the river. The remainder of the catchment is covered by the Witwatersrand Series and Dolomite around Johannesburg, the Pretoria Series, Dolomite and Witwatersrand Series around Vereeniging, the Ventersdorp System around Bloemhof and Warrenton, and the Dwyka Conglomerate in the neighbourhood of Barkly and Kimberley.

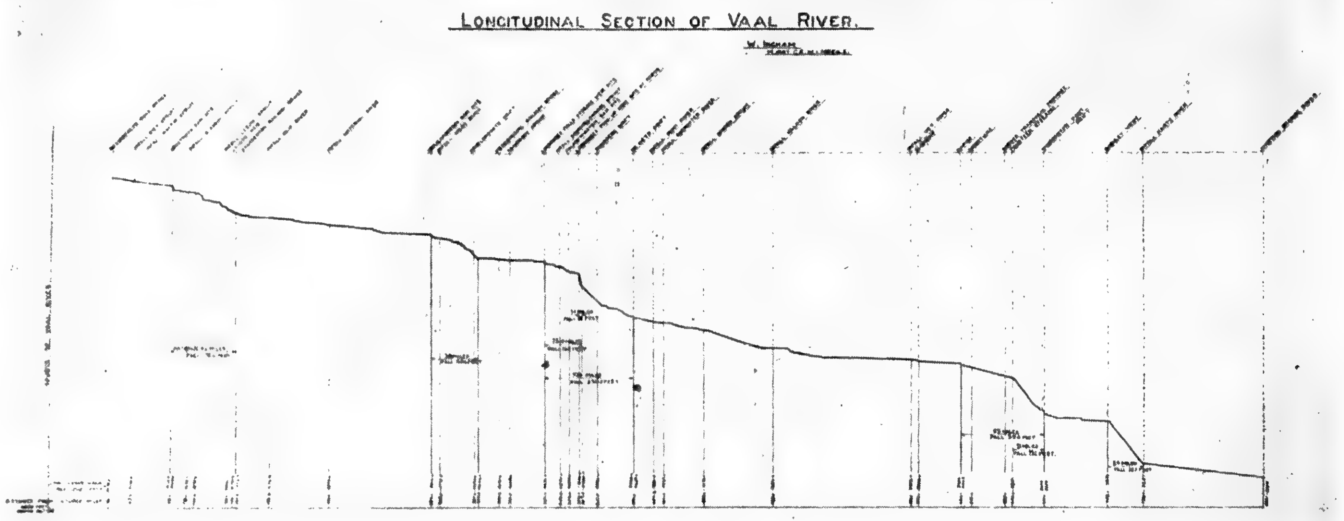
It is a peculiarity of the left bank of the Vaal that there are large tracts of sand, whereas the right bank is fairly free of such deposits. Below Christiana there are considerable areas of calcareous tufa, and the soil is generally very poor in such districts.

Afforestation.

There are ample facilities for tree planting within the Vaal River Catchment Area, and as mining and building timber is,



W. Ingham.—The Vaal River and its Possibilities.



W. Ingham.—The Vaal River and its Possibilities.

and will be, in great demand, it will well repay landowners to plant trees on land which is unsuitable for cultivation in other respects. The time required for trees to mature for providing timber for industrial purposes will range, according to locality and rainfall, from 8 to 15 years. The cost of planting, clearing, supervising during growth, cutting down and preparing for the market will be about £10 per acre, whereas the value when ready for felling will be in the neighbourhood of £30 per acre. Many farmers are unaware of the value of timber trees, and it is suggested that the Government Forest Department should circulate information with reference to this matter to all farmers within the Union. Apart from the monetary return for the trees, the fact of there being large plantations all over the catchment will tend to increase the rainfall to some extent, but the principal advantages will be obtained owing to the dry weather flow of the river being increased and the maximum flood discharge being less. This is a very important matter, for within the last few years the Vaal River has been absolutely dry at certain places between Parys and its junction with the Orange River.

Rainfall Records on the Vaal River Catchment Area.

A table (B) is appended, which shows the rainfall at various places within the Vaal River catchment area. As, however, the records have not been observed in many cases over a sufficiently long period to give correct averages, the number of years has been stated in the third column of the table. The reference numbers in the first column locate the position of the rainfall station on Plate 2.

A summary of the averages of each particular catchment is also given in table (C), and the reference letters are shown on the map.

It will be observed that the rainfall varies very considerably over the Vaal River catchment area. For instance, the Riet River area has a rainfall of only 13.58 inches, as compared with 31.8 inches for the Wilge River. These rainfalls are for fairly large areas, and individual rain gauges will register falls from about 10 inches in the lower portion of the catchment to 45 or 50 inches at the sources of the Vaal. A fall of 14 inches has been recorded within a period of 24 hours at Krugersdorp, and 3 to 4 inches have been recorded in an hour on several occasions in the Transvaal.

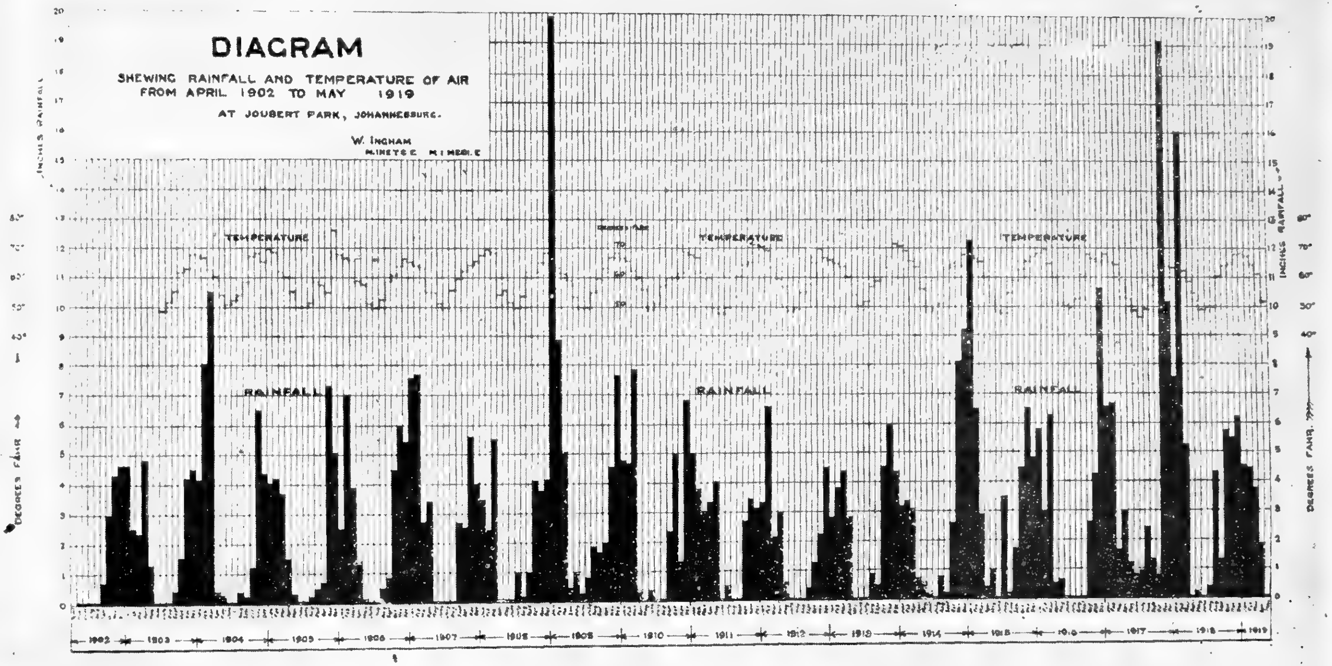
The rainfall records at Joubert Park, Johannesburg, for the years 1902-1919 inclusive is shown on Plate 5.

TABLE A.

The following list shows the approximate distances from the source of the Vaal River to various points on the river and the approximate catchment areas.

From Source of Vaal to.	Distance in Miles from Source.	Catchment Areas of the Vaal River in Square Miles.	Catchment Areas of Tributaries in Square Miles.
Standerton Weir	129	3,293	—
Standerton Town	131	—	—
Junction of Klip River, O.F.S.	153	—	1616
Villiersdorp	199	—	—
Junction of Wilge River	265	—	5816
Junction of Zuikerbosch-rand River	296	—	1328
Junction of Rand Klip River	297	—	925
Vereeniging	303	—	—
Junction of Taaibosch-spruit	311	—	358
Junction of Rietspruit	324	—	368
Barrage at Lindeques	325	17,119	—
Parys	348	17,691	—
Venterskroon	363	—	—
Junction of Mooi River	404	—	1450
Junction of Rhenoster River	411	—	2910
Coal Mine Drift, Klerks-dorp	431	23,579	—
Junction of Schoon Spruit	437	—	1369
Junction of Valsch River	482	—	2230
Junction of Vet River	572	—	7458
Bloemhof	578	—	—
Christiana	613	43,487	—
Fourteen Streams	640	—	—
Warrenton	642	—	—
Windsorton	661	—	—
Kimberley Waterworks	677	46,087	—
Barkly Bridge	702	—	—
Junction of Harts River	726	—	11422
Junction of Riet River	787	—	11220
Douglas	796	—	—
Junction with Orange River	805	73,747	—
Mouth of Orange River	1408	—	—

The above distances have been taken from the longitudinal section of the Vaal River. (Plate 4.)



W. Ingham.—The Vaal River and its Possibilities.

TABLE B.

SUMMARY OF RAINFALL RECORDS ON VAAL RIVER CATCHMENT AREA UP TO DECEMBER 31ST, 1918.

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
1	Campbell	23	12.80
2	Douglas	36	12.84
3	Boetsap	17	18.11
4	Bellsbank	23	15.08
5	Barkley West	34	16.81
6	Vryburg	31	18.37
7	Kimberley	34	17.11
8	Taungs	19	16.38
9	Rocklands	10	14.32
10	Sunnyside	9	12.12
11	Warrenton	8	14.85
12	Jacobsdal	25	17.36
13	Koffyfontein	13	14.05
14	Roodepoort	9	22.19
15	Petrusberg	13	12.60
16	Fauresmith	14	15.37
17	Jagersfontein	18	17.90
18	Klipnek	12	16.98
19	Lokshoek	9	15.37
20	Boomplaats	11	13.74
21	Karreefontein	10	17.28
22	Highbury	9	16.74
23	Dealesville	8	15.72
24	Paardekraal	8	16.00
25	Bakfontein	5	17.61
26	Hoopstad	13	20.41
27	Bellevue	12	30.23
28	Excelsior	13	13.73
29	Bethanie Village	6	20.57
30	Abercairn	12	16.51
31	Fairfield	14	23.05
32	Bains Vlei	13	16.26
33	Reddersburg	11	18.72
34	Retreat	8	22.58
35	Tempe	10	20.22
36	Vooruitzicht	9	17.30
37	Bloemfontein	30	22.05
38	Ellerslie North	12	20.21
39	Groot Vlei	8	19.55
40	Glen Lyon	11	19.91
41	Vergezicht	10	19.33
42	Devon Farm	7	20.43

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
43	Mazels Poort	13	20.24
44	Klip Pan	10	18.45
45	Hosell	8	18.94
46	Lucerne Valley	9	19.07
47	Sannah's Post	12	15.95
48	Botha Ville	11	22.75
49	Nieuwjaarsfontein	12	21.08
50	Ramalitsi Farm	10	22.85
51	Odendaals Rust	12	19.89
52	Rockwood	10	21.15
53	Roodepoort	12	16.13
54	Boachoko	4	22.54
55	Wildebeestefontein	8	22.12
56	Vierfontein	9	24.09
57	The Cliffs	12	22.85
58	Wilgeboomnek	14	23.00
59	Groot Hoek	6	27.58
60	Newlands	10	14.99
61	Thabanchu	21	24.16
62	Thorley	9	23.54
63	Maccaw Vlei	13	28.24
64	Fairfield	12	27.41
65	Lindley	18	24.67
66	Viljoen's Drift	11	26.55
67	Wexford	9	28.37
68	Lindley Road	9	23.71
69	Kroonbank	12	26.82
70	Hammonia	12	27.94
71	Roodepoort	8	21.58
72	Vischgat	8	25.21
73	Honingskloop	5	25.58
74	Senekal	10	25.83
75	Lambertina	9	26.11
76	Parys	13	26.20
77	Hayfield	11	23.08
78	Kroonstad School	14	21.88
79	Congleton	11	25.36
80	Zorgvleit	8	20.92
81	Roodekop	10	23.47
82	Bantry	10	24.29
83	Carrisbrooke	10	23.21
84	Westminster	14	24.26
85	Burnet Holme	10	21.67
86	Ventersburg	8	20.37
87	Geduldfontein	7	22.30
88	Tweespruit	13	24.09

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
89	Excelsior	7	18.60
90	Holfontein	10	26.69
91	Mt. Stephen	11	24.53
92	Dekselfontein	10	32.92
93	Kaallaagte	11	27.17
94	Kalkonenkrantz	11	30.22
95	Middle Punt	13	27.26
96	Retreat	9	22.42
97	Novo	13	29.83
98	Wilgeboom	11	25.51
99	Zandoog	9	28.64
100	Vryheid	14	26.59
101	Abersethin	11	28.82
102	Bethlehem	11	24.77
103	Broomsland	7	23.49
104	Reitz	14	28.47
105	Villiers	10	28.81
106	Stolzkop	10	28.52
107	Belladale	9	30.65
108	Kastell	9	30.36
109	Dunelm	11	31.11
110	Bethanie	10	19.11
111	Witzieshoek	9	31.47
112	Woudzicht	8	33.18
113	Buckland Downs.	12	31.68
114	Vrede	14	28.72
115	Harrismith	21	28.95
116	Elizabeth	11	24.00
117	Groothoek	6	27.58
118	Houthoek	10	32.01
119	St. Hubert	9	30.06
120	Driefontein	7	29.74
121	Memel	6	26.19
122	Galaxy	9	27.79
123	Lincolnshire	11	38.10
124	Mizpah	6	28.25
125	Koppieskraal	12	20.42
126	Vecht Valley	12	17.56
127	Elsendale	8	17.62
128	Christiana	8	16.87
129	Schweitzer Reneke	12	18.54
130	Poortje Farm	12	19.81
131	Zetland	9	17.60
132	Bloemhof	15	18.66
133	Doornbult	8	23.46
134	Kaal Pan	6	20.85

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
135	Kareebosch	8	29.77
136	Collendrina	6	17.55
137	Lucas Kraal	8	20.62
138	Wolmarans Stad	10	22.01
139	Maquassie	8	18.55
140	Wondilla	13	20.19
141	Mimosa Vale	10	20.41
142	Lichtenburg	15	23.44
143	Palmietfontein	10	21.71
144	Doornhoek	4	19.58
145	Diepkuil	10	20.16
146	Leeuwfontein	10	22.18
147	Matzosspruit	11	21.88
148	Hartebeestefontein	9	25.66
149	Putfontein	11	22.73
150	Doornplaats	8	22.39
151	Riet Kuil	8	22.19
152	Kaffir Kraal	10	21.41
153	Klerksdorp	19	22.98
154	Palmietfontein	7	19.57
155	Machavie	14	24.37
156	Roodekop	9	23.01
157	Koekemoer	13	23.78
158	Ventersdorp	11	23.99
159	Langlaagte	12	32.21
160	Maraisburg	14	30.05
161	Hartzenbergfontein	4	19.04
162	Vereeniging	18	28.20
163	Klipspruit	9	30.06
164	Kromdraai	9	30.56
165	Florida	14	33.22
166	Bodworth.	14	28.51
167	Van Wyksk	8	29.71
168	Roodepoort (Maraisburg)	13	35.16
169	Zuurbekom	14	28.93
170	Kalboschfontein	7	27.84
171	Bloemhof	6	31.86
172	Bank	15	23.48
173	Leeuwpoort	9	28.43
174	Holfontein	7	25.26
175	Koppieskraal	12	25.89
176	Welverdend	8	24.53
177	Turffontein	13	24.35
178	Gerhard Minebrow	11	23.36
179	Rooidraai	7	23.74
180	Klerkskraal	15	24.89

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
181	Mooibank	14	23.38
182	Boskop	13	25.07
183	Elandsheuval	15	25.16
184	Potchefstroom	15	25.15
185	Buckingham	12	27.34
186	Booysens Spruit	13	32.15
187	Braamfontein	14	34.01
188	Burgersdorp	8	32.50
189	West Turffontein	12	32.31
190	Vierfontein	13	28.29
191	Joubert Park	29	33.58
192	Withoek	13	24.86
193	Heidelberg	15	29.29
194	Nigel	13	28.49
195	Springs	14	27.03
196	Vlakfontein	13	29.65
197	Grootfontein	4	29.94
198	Grootvlei Coll.	11	28.59
199	Zwartkopjes	11	29.91
200	Balfour	12	29.97
201	Rietvlei (S.A.R.)	12	28.55
202	Kraal	10	31.71
203	Van Kolders Kop	12	32.37
204	Greylingstad	13	31.67
205	Vai	10	25.62
206	Hayfields	12	26.51
207	Cleveland	7	29.89
208	Germiston	11	32.35
209	Boksburg	13	28.46
210	Witkleinfontein	10	32.37
211	Rietvlei	12	24.17
212	Leslie	10	28.58
213	Holmdene	5	25.47
214	Trichardsfontein	14	22.12
215	Standerton	13	28.89
216	De Lange Drift	8	25.58
217	Standerton (Gov. Farm)	7	30.46
218	New Denmark	14	27.80
219	Driehoek	10	26.64
220	Goedgedacht	8	25.55
221	Kareebosch	7	30.43
222	Kromdraai	11	25.44
223	Weltevrieden	9	31.01
224	Platrand	14	27.49
225	Newlands Farm	7	31.83
226	Cranborne	14	30.66

Reference No. on Plan.	Name of Station.	Period of Record in Year.	Average Annual Rainfall in Inches.
227	Hendriks Pan	8	32.23
228	Koppy Alleen	6	31.09
229	Beckers Rust	12	30.51
230	Streekfontein	8	31.35
231	Strydkraal.	5	28.55
232	Paardekop	8	29.35
233	Vlei Plaats	15	30.47
234	Palmford	9	29.44
235	Zandspruit	9	27.73
236	Rietpoort	11	32.04
237	Amersfort	10	30.64
238	Oudehoutkloof	8	31.35
239	Uitzicht	12	28.73
240	Graskop	11	33.34
241	Goed Hoop	13	29.91
242	Ermelo	15	31.52
243	Families Hoek	7	29.92
244	Kliprug	4	36.22
245	De Emigratie	13	30.00
246	Holbank	10	37.87
247	Camden	13	33.75
248	Kranzpan	12	36.59
249	Rooipoort	8	30.72
250	Rolfontein	13	29.54
251	Bloemhof	6	30.12
252	Vaalbankspruitdrift	9	33.75
253	Zoutpan	8	14.22
254	Blesbokfontein	8	13.74
255	Zandfontein	8	17.10
256	Palmietfontein	6	18.37
257	Axhboschdam	4	12.01
258	Smithkraal	8	15.41
259	Aurora	8	13.72
260	Kanonfontein	5	15.85
261	Eagles Nest	6	14.18
262	Doornplat	8	16.12
263	Kuil Put	8	17.26
264	Aboretum	7	20.05
265	Sydney-on-Vaal	8	13.57
266	Newlands	34	16.90
267	Witkoppies	9	26.55

TABLE C.

The following table shows the average annual rainfall over the various catchments:—

Ref. letter on Plan.	Name of Catchment.	Area of Catchment Sq. miles.	Number of Years.	Average Rainfall in Inches.	Remarks.
A	*Vaal River at Standerton	3,293	14	30.26	Right bank.
B	x Zuikerboschrand River	1,328	11 to 15	29.45	,,
C	xRand Klip	925	4 to 29	28.74	,,
D	xRietspruit	368	4 to 14	29.25	,,
E	*Mooi River	1,450	14	24.37	,,
F	*Schoonspruit	2,233	14	22.23	,,
G	xHarts River	11,422	4—34	17.75	,,
H	*Klip River, O.F.S.	1,616	12	30.84	Left bank.
	xWilge River	5,816	6 to 21	28.97	,,
J	xWilge River at Frankfort Weir		4	31.80	,,
K	xTaaibosch Spruit	358	No records		,,
L	xRhenoster River	2,910	5 to 12	26.20	,,
M	*Valsch River	2,230	5	22.76	,,
M	xValsch River	,,	8—18	24.55	,,
N	xVet River	7,458	8 to 14	24.66	,,
O	*Riet River at Koffyfontein	4,542	6	13.58	,,
P	xRiet River at junction with Vaal River.	11,220	6—30	18.94	,,

NOTE.—The records marked * were obtained from the Hydrographic Surveyor of the Irrigation Department. Those marked x were compiled from the records of the Chief Meteorologist, Irrigation Department, Pretoria, and the average rainfall is only approximate.

Evaporation Records.

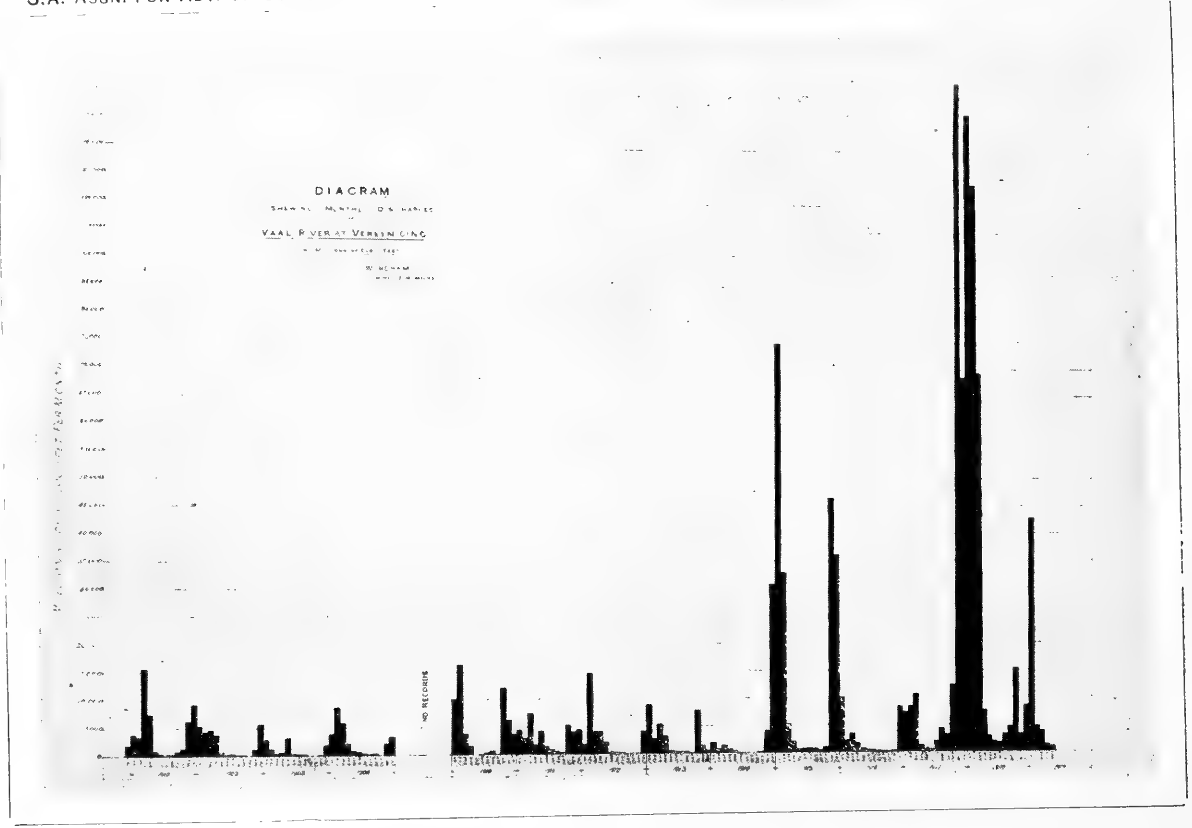
The records at the Union Observatory at Johannesburg show that the average yearly evaporation from a water surface over a period of 15 years (1904-1918) is 67.97 inches, with a maximum of 92.31 inches and a minimum of 51.64 inches respectively. The average monthly evaporation over the period of 14 years is shown below:—

Month.	Inches.	
January	6.05	
February	5.34	
March	4.94	
April	4.80	
May	4.38	
June	3.85	minimum
July	4.34	
August	5.63	
September	7.14	
October	7.55	maximum
November	7.23	
December	6.74	

The annual evaporation from a *water surface* at Johannesburg and Kimberley is as follows:—

Year.	Johannesburg Inches.	Kimberley Inches.
1904	92.31	
1905	84.72	
1906	70.10	
1907	76.69	
1908	66.59	
1909	69.57	
1910	64.97	91.7
1911	71.91	86.4
1912	68.89	90.3
1913	69.72	89.6
1914	61.00	90.0
1915	55.60	91.6
1916	61.76	92.8
1917	54.04	78.9
1918	51.64	
Averages	67.97 (15 years)	88.91 (8 years)

It will be observed that the evaporation at Kimberley for the 8 years is 88.91 inches, as compared with 63.49 inches for the same years at Johannesburg.



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Temperatures.

At the Union Observatory, Johannesburg, the maximum and minimum temperatures during each month of an average year are as follows:—

Year 1918.	Maxium in degrees Fahrenheit.	Minimim in degrees Fahrenheit.
January	84.3	42.0
February	80.1	44.8
March	77.5	46.2
April	77.0	37.4
May	72.0	24.9
June	65.3	30.9
July	68.2	25.1
August	71.0	33.3
September	78.9	37.0
October	83.1	45.3
November	82.6	43.8
December	85.2	47.4

The above figures were kindly supplied by the Union Astronomer (Mr. R. T. A. Innes).

The maximum daily temperature recorded was 90°F. on the 23rd December, 1913, and the minimum was 23.1°F. on the 16th July, 1906.

The monthly variations over the year are very regular, as will be observed by an examination of Plate No. 5.

In the Klip River Valley the daily variations are much more pronounced, and 105°F. as a maximum and 5°F. as a minimum have often been recorded at the Zwartkopjes and Zuurbekom Pumping Stations of the Rand Water Board.

Influence of Temperature upon Evaporation.

Some interesting experiments were carried out under my supervision at the Village Pumping Station of the Rand Water Board in January last to ascertain the evaporation of water at different temperatures, and the effect of such increase is shown on Plate 3.

The test was carried out with water at its natural temperature, which was about 73°F., and also with artificial temperatures of about 83°F. and 90°F. The tanks, which were 4 feet square, contained 3 feet 6 in. of water, and were erected at the Village Main Pumping Station, in the centre of Johannesburg. There were three tanks, one under natural conditions, and the other two were heated artificially by watertight steam coils passing through the water contained in the tanks. As all other factors were common to the three tanks the difference in evaporation was due to temperature alone.

The experiment was commenced on the 1st January, 1919, and the results are shown graphically on Plate 3 for a period of 18 days. The daily evaporation, at the Union Observatory, for the same period, is also shown on the chart. Readings were taken every half-hour during the 24 hours of each day, and the necessary corrections were made for rainfall. The experiment definitely shows that there is a *considerable increase* in evaporation as the temperature of the water increases, and the results are shown below:—

Temperature from	Daily Evaporation for each 1° F. rise in Temperature.
67.31° F. to 73.36° F.	0.013 inches.
73.36° F. to 82.71° F.	0.018 inches.
82.71° F. to 90.44° F.	0.023 inches.

The actual evaporation in inches during the 18 days is given below:—

Average Temperature Fahrenheit	Evaporation in Inches.	Remarks.
67.31	3.280	Tank at Union Observatory (Johannesburg).
73.37	4.687	Village Pumping Station Tank.
82.71	7.727	Do. Do.
90.44	10.918	Do. Do.

It will be observed from the above figures that for a rise in temperature of about 23°F. the evaporation increased from 3.28 to 10.92 inches in 18 days. Evaporation is also affected by many other factors, such as wind, humidity, etc., but it is unnecessary to discuss these factors in this paper.

If, therefore, the natural temperature of a river is raised owing to water being used by Power Stations for condensing purposes, it follows that the loss due to evaporation in the river is considerably increased. Based upon an increase in temperature of 18°F. (72.5 to 90.5), and taking an area of one square mile of river, which represents a stretch 11.7 miles long by 450 feet wide, the additional loss above that due to natural evaporation is 5,338,000 gallons per day.

A case in point has been recently considered in connection with the Rand Mines Power Company's station at Vereeniging, when it was clearly shown before the Parliamentary Select Committee that the extra loss from the Rand Water Board reservoir, due to condensing water being returned to the river, would be about 300 million gallons per annum if the circulating water for condensing was 18°F. higher than the natural temperature of the river water.

It was also found during the investigations that the natural temperature of the river water at 9 o'clock in the morning is approximately equal to the mean temperature of the air during the day.

Quality of Water.

In the first sample (see chemical analyses) the solids were 868 per million, and in the second only 180 per million, as compared with 1,050 under the worst conditions.

It will be observed that the total hardness increases as the quantity of water flowing in the river decreases. This is due to the increasing proportion of dolomitic water as the flow in the river decreases. The samples taken for bacterial examinations shows that the water is remarkably free from the ordinary organisms usually found in river water, and the number of bacteria is also very small for such a river. This is no doubt due to the amount of silt carried by the river.

The first chemical sample was taken in February, when the river was discharging 1,220 cubic feet per second, and the second sample when only 80 cusecs were passing. The sample taken for bacteriological examination was taken on the same date as that for chemical analysis, on the 27th June, 1913.

Chemical Analyses of the Vaal River Water.

The following analyses were made by the Government Analyst (Dr. McCrae) of two samples of water taken at a point 400 yards above the Railway Bridge at Vereeniging on the 3rd February, 1913, and on the 27th June, 1913:—

Analyses.

(*Results expressed in parts per* 100,000.)

	Discharge of River 1220 cu. secs. No. 1 3/2/1913.	80 cu. secs No. 2. 27/6/1913.
Total Solids	86.8	17.95
Loss on Ignition	9.95	5.8
Chlorine	0.6	0.5
Nitric Nitrogen	Nil	Nil.
Nitrous Nitrogen	Nil	Nil.
Saline Ammonia	0.0036	0.0016
Albuminoid Ammonia	0.0688	0.0112
Oxygen absorbed (4 hours at 27° C.)	0.44	0.14
Total hardness	7.08	9.6
Permanent hardness	—	2.0
Poisonous Metals	Nil	Nil.
Iron	Heavy	(Appreciable amount.)
Dissolved Solids	10.2	
Loss on Ignition	6.65	
Suspended Solids	76.6	....
Loss on Ignition	6.65	
Oxygen absorbed in 4 hours by the clear water	0.056	

No. 1.—The suspended matter consists of clay and sand. On addition of alum the suspended matter deposits well. The sample is remarkably free from water organisms (apart from bacteria).

No. 2.—The turbidity is due to light sand and clay. On standing, the sand deposits, but the clay remains in suspension. Addition of alum causes a ready deposition of the clay.

Bacteriological Examinations.

The water has been examined by Dr. W. Watkins-Pitchford, the Government Bacteriologist, with the following results:

The samples of water in this case were taken on June 27th, 1913, and sample "A" is similar to the chemical sample (No. 2) taken on the same date.

B2020/13. A. *At Vereeniging Weir.*

53 organisms per c.c. growing at 37°C.
B. coli present in 1 c.c., not isolated from 0.1 c.c.

B2021/13. B. *Above Vaal River Bridge.*

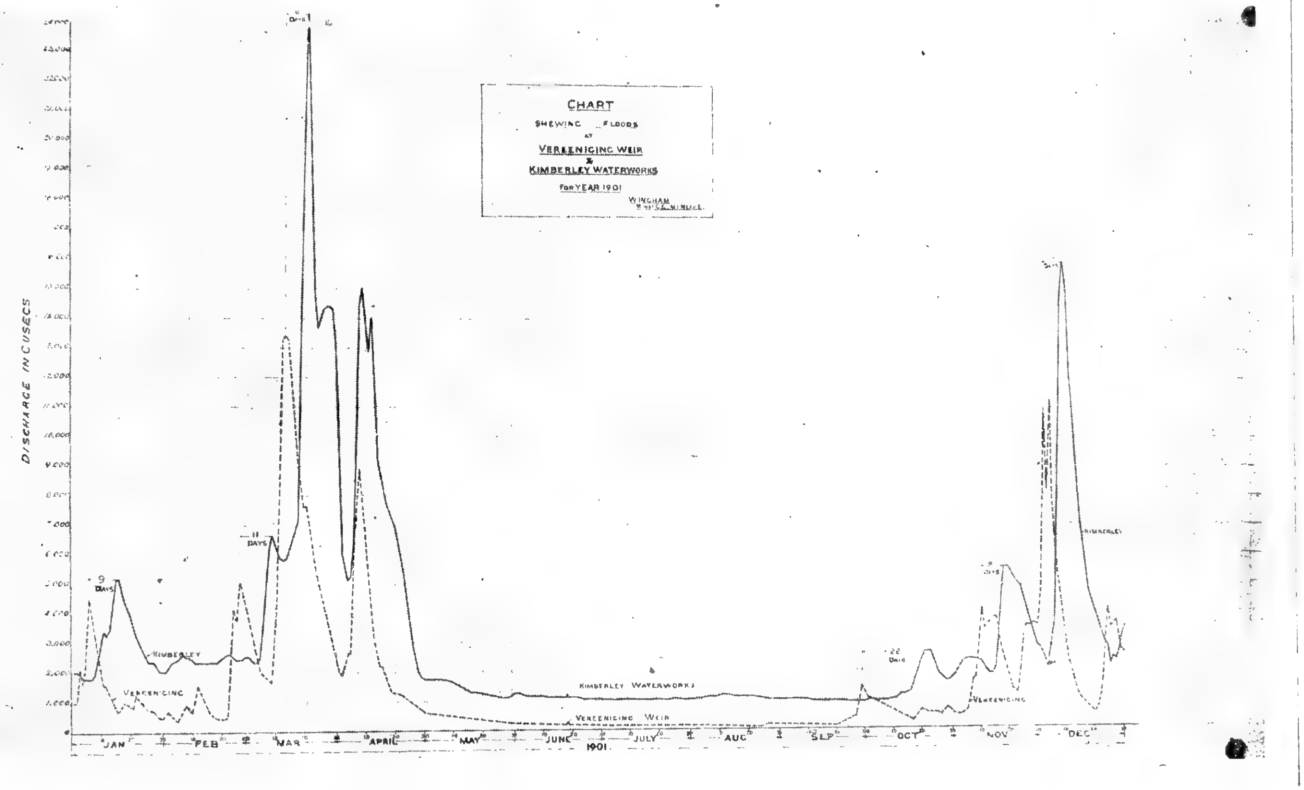
30 organisms per c.c., growing at 37°C.
B. coli present in 1 c.c., not isolated from 0.1 c.c.

Silt and Solid Matter carried by the Vaal River.

The silt contents of any river varies with the discharge, but is also affected by the incidence of the rainfall and the amount of rain which previously fell on the catchment area. For instance, the greatest amount of silt is usually found in a river when there is a heavy fall of rain following immediately after a dry period at the commencement of the rainy season. It is also usual for the water in a rising flood to have a greater silt content than in a falling one. In the Vaal River the silt content varies considerably, and the greatest quantity up to the present at Vereeniging has been 1,050 parts per million parts of water by weight as compared with 1,500 parts per million in the River Nile (Egypt). Sir W. Wilcocks estimates that the River Nile discharges 13,000,000 million gallons of water into the Mediterranean during an average year, and that the total solid matter contained in that quantity is no less than 36,600,000 tons.

Some impression of the silt contents of the Vaal River can be obtained by perusing the following figures. The average flow of the Vaal at Kimberley over a period of 30 years is 4,587 cusecs, and this is equal to an average annual discharge of 904,000 million gallons.

Taking the average amount of silt at 700 parts per million, the total weight will be 3,164,342 short tons, or 42,191,226 cubic feet, and this will cover 1,935 acres to a depth of 6 inches.



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The solids in suspension at the Kimberley Waterworks for ten samples taken at various times has varied from 7 to 2,872 parts per million, or an average of 687 per million, as shown in the following table:

Solids in Suspension in Parts per Million. *

	2872.0
	164.0
	16.0
	7.0
	1271.0
	277.0
	981.0
	557.0
	499.0
	163.0
Average per 10 samples	687.3

Discharge of the Vaal River.

The quantity of water passing down the Vaal River during the years 1900 to 1905 and 1910 to 1919 is shown in Table "D." The discharges during the former period, 1900-1905, were obtained by Mr. Laschinger, and during the latter period by the Government Irrigation Department and the Rand Water Board. Table "E" shows the average monthly discharge over a period of 13 years, and it will be observed that January is the month of greatest flow, and June that of lowest flow.

Table "F" shows the discharge in cubic feet, the average annual rainfall, and the percentage run-off. The run-off, as will be observed, varies very greatly, the lowest being 1.55 per cent. during the hydrographical year 1913-1914, and the highest 35.25 per cent. during the year 1917-1918.

The monthly discharge of the Vaal River at Vereeniging for the years mentioned above is shown graphically on Plate 6. Plate 7 shows the discharge of the Vaal River at Vereeniging and Kimberley for a period of one year, and it will be observed that the time lag with reference to floods usually varies from about 7 to 11 days.

* These figures have been supplied by F. S. Lynch, Esq., General Manager, Kimberley Waterworks.

TABLE D.

Total Monthly Discharges of the Vaal River at Vereeniging in Million Cubic Feet.

Hydrographic Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August	September.	Total Discharges.
1900-1901	—	—	1897·197	3880 189	3423·124	15518·183	7395·969	984·528	454·360	407·246	258·569	731·091	34950·455 10 months only.
1901-1902	1355·469	6108·246	9214 413	5329·601	4301·994	4645 667	3834·544	629·311	239·328	261·593	159 710	96 474	36176·350
1902-1903	61·888	1060·793	5557·420	2975·754	1378·399	346·204	611 521	3332·620	420·958	242 637	158 716	37·532	16184·442
1903-1904	14 506	78·235	1963·656	3967·004	8797·368	58251·778	2466 315	957·277	577·722	388 609	258 716	60·955	77582 141
1904-1905	42·405	2183·587	3439·851	—	—	—	—	—	—	—	—	—	5665·843 3 Months only.
1910	—	—	—	10095·24	16385·95	37621 27	1520·12	—	45·02	265·01	590·27	215·63	66738·51 8 months only.
1910-1911	12081·56	6345·95	3670·59	44610 05	2879·29	7482·22	1694·74	4256·37	1424 74	849·93	464·34	332 12	86091·90
1911-1912	5286·86	4187·84	4501·48	1722·65	14646·78	4103·25	4049·95	2134·94	426·92	296 36	172 88	61 74	41591 65
1912-1913	—	547·54	4073·02	8844·53	2678 15	5382·51	3091·55	453·53	235 21	185 75	196·13	79 74	25767·66 11 months only.
1913-1914	7796·21	1375·64	380 00	1753·06	621·36	1499·30	540·26	138·21	78·97	48·48	24 87	22 06	14278·42
1914-1915	171·17	4041 06	30743·93	74710·51	32843·19	5077·15	1878·92	697 75	586·39	689 46	672·63	221·64	152333 80
1915-1916	1178 20	46509·00	36017·70	9957·20	2159·00	3332·60	1562 50	547·50	425·26	323 13	257 00	137·20	102406 29
1916-1917	38·00	81·00	8470·00	7261·00	8400·00	10552·00	1062·55	573·00	372·64	1839 30	4256·60	3192·00	46158·09
1917-1918	12427·00	125048 00	68691·00	117485·00	101850·00	69306·00	7705·00	2960 00	1946 00	1586 50	5678·60	4619 80	522302 90
Monthly Average	3677·6	16463·9	13740·02	22507·06	15581·90	17162 93	2862·61	1472·08	556·42	572 61	1011 46	754·46	
1918-1919	15488·00	3243·00	8655·00	42481·00	4705·00	3950·00	1440·00	1108·40	Incomplete Year.				

TABLE E.

Taking the average flow per month of the Vaal River at Vereeniging over a period of 13 years (1900-1905 and 1910-1918), the discharges are in the following order:—

Month.	Million Cubic Feet.
1. January (Highest)	22,507
2. March	17,163
3. November	16,464
4. February	15,582
5. December	13.740
6. October	3,678
7. April	2,863
8. May	1,472
9. August	1,011
10. September	754
11. July	573
12. June (Lowest)	556

TABLE F.

DISCHARGE OF VAAL RIVER AT VEREENIGING.

Hydrographic Year October to September.	Discharge in Million Cubic Feet.	Average Annual Rainfall in Inches.	Percentage run off	Remarks.
1900-1901	34,950			10 months only.
1901-1902	36,176			
1902-1903	16,184			
1903-1904	77,582			
1904-1905	5,666			3 months only
1910	66,738			8 months only.
1910-1911	86,092	33.57	6.97	
1911-1912	41,592	25.39	4.45	
1912-1913	25,768	28.57	2.43	11 months only, October missing.
1913-1914	14,278	25.00	1.55	
1914-1915	152,334	29.72	13.92	
1915-1916	102,406	26.62	10.45	
1916-1917	46,158	33.60	3.74	
1917-1918	522,303	40.26	35.25	
1918-1919	81,070	—	—	8 months only.

NOTES.—The discharge figures for the period 1900 to 1905 are from a catchment area of 15,839 square miles, and for the period 1910-1919 from an area of 16,319 square miles.

No rainfall records over the catchment area are available for the period 1900-1905, so that the run-off percentages cannot be calculated.

Irrigation by Pumping.

The question of pumping water for irrigation has been discussed on many occasions, and I wish once again to state that irrigation by pumping will pay in every case where the higher-priced crops can be grown. Take lucerne (alfalfa) as an example. The quantity of water required *per acre crop* may be taken at about 100,000 gallons, which is about a 4½-inch watering. A ton of dried hay can be obtained per acre crop, and at 5s. per 100 lbs. the return will be £5. The revenue for six crops each year will therefore be £30, and after deducting, say, £15 for working expenses, such as harvesting, transport, railage, marketing, etc., there is a balance of £15, or £2 10s. per crop.

Water can be raised at less than 1d. per 1,000 gallons for lifts of under 100 ft. by well-designed pumping plants; so, taking 600,000 gallons as the quantity of water required for six crops, the cost at 1d. per 1,000 gallons will be £2 10s., or 8s. 4d. per acre crop. This leaves a profit of £2 1s. 8d. per acre crop, or £12 10s. per acre annum. Land under such conditions, which is worth about £4 to £8 per acre before being irrigated, is often worth from £100 to £180 per acre when planted with lucerne or first-class citrus trees of five years' growth.

Existing Irrigation Schemes.

The existing storage and gravitation schemes above the confluence of the Vaal and Orange Rivers irrigate about 3,200 acres, while the existing pumping plants irrigate about 7,000 acres. There are at present 43 pumping plants between Vereeniging and the confluence, and it is estimated that there are about 60 pumping plants on the whole length of the Vaal.

Estimated Area of Irrigable Land.

About 500,000 acres are available for irrigation within the Vaal River catchment area, and the greater portion of the area is downstream of Vereeniging. The quantity of water required for irrigating 500,000 acres, taking an all-round figure for the various classes of crops and fruit trees, will be about 50,000 million cubic feet, and owing to occasional years of low flow, it will be absolutely necessary to impound sufficient water in storage reservoirs to cover a period of at least 18 months. It should, however, be mentioned that although the catchment area above Vereeniging is only 16,319 square miles, as compared with 46,087 square miles at Kimberley, the actual discharge at Kimberley over the period 1900-1904 was only 1.9 times as much as at Vereeniging.

Generation of Power from Coal-fields Adjoining the River.

There are several places on the Vaal River coal-fields where cheap electrical power can be generated for driving pumping

plants for irrigation. The power could be generated at the pit-mouth in the neighbourhood of Vereeniging, Coal Mine Drift, or other suitable sites, and a transmission line erected on the bank of the river for driving pumps situated on the pools about one mile apart for a distance of 100 miles up and downstream of the central stations. The transmission line could also be used for driving agricultural implements and machinery. Fertilizers could also be made from coal at the central stations, and from such a combination of consumers a good load factor would be obtained. The line losses would be comparatively small (about 10 per cent.), and the price of current should not exceed 0.4d. to 0.5d. per unit at the point of usage.

The Rand Mines Power Company is in an excellent position for providing such power in the neighbourhood of Vereeniging, and as the selling price of current at present is only 0.525d. per unit on the Rand, there is no reason why a lower price should not be obtained if a large number of farmers agreed to take current.

Although there are few places on the Vaal River suitable for power development on a large scale without impounding reservoirs, there are many places where small power stations can be installed. The erection of large power stations on the lines referred to above would, however, probably be cheaper than a number of individual small schemes. Two small turbines, each about 50 h.p., have now been installed at Parys; but this power can easily be increased by piping the water from the present weir to the lower end of the falls.

Conservation of Water.

The question of conservation of water is one which should be seriously considered in connection with all South African rivers, as the quantity of water which is allowed to run to waste into the sea is simply appalling. The Vaal River at Vereeniging discharges from 89,237 million gallons in a dry year to 3,264,400 million gallons in a wet one, and it is hoped that a large proportion of this water will, sooner or later, be impounded for irrigation and industrial purposes.

One of the principal difficulties will be the silt problem, but this can be overcome by the provision of barrage gates or a sufficient number of under sluices in solid dams. A good example of the former method is now under erection by the Rand Water Board at the Vaal River Works, about 25 miles downstream of Vereeniging, and the reservoir in this case will back up the Vaal River for a distance of nearly 40 miles. The quantity of water impounded by the Rand Water Board barrage will be 13,633,000,000 gallons, and the total cost will be about £285,000, or £21 per million gallons stored. If the water was used for irrigation instead of supplying water for domestic and industrial purposes to the Rand, the area of which could be irrigated would be about 25,000 acres. The cost of impounding is, therefore,

reasonable, if large irrigable areas are available within a reasonable distance from a dam site.

Irrigation Act No. 8 of 1912.

According to the Irrigation Act No. 8 of 1912, the water of a public stream is subject to use for primary, secondary, and tertiary purposes.

(A). Primary use is for water used by stock and for domestic purposes.

(B). Secondary use is for irrigation.

(C). Tertiary use is for mechanical or industrial purposes.

The development of power will, therefore, come under tertiary use; but the water is subject to a reasonable secondary use for lower riparian owners.

In storing water for tertiary purposes provision must, therefore, be made for the protection of lower riparian owners, and the Water Court will fix the "normal flow" of the stream. This is, in practice, usually based upon the dry weather flow during the months of May, June, July, August, September and October, but it does not follow that such a period is or will be taken as the basis.

In the case of the Rand Water Board's Act, the average flow per day, taken over a period of 10 years for the months May to October (inclusive), was taken as the basis, and although the actual figure was only 167 cusecs, the normal flow at the barrage site was fixed at 250 cusecs.

Monthly Discharge of the Vaal River.

It will be observed, by referring to Table "E," which gives the average monthly flow of the Vaal River at Vereeniging over a period of 13 years, that the greatest average monthly flow is in January, with 22,507 million cubic feet, while the lowest average monthly flow is in June, with 556 million cubic feet. During October, 1903, the registered quantity at the Vereeniging weir for the month was only 145 million cubic feet. The lowest recorded daily flow at the Vereeniging weir has been 4 cusecs; but the Vaal River, below Parys, has stopped running for several weeks together during a very dry season. It therefore follows that either auxiliary steam or oil plant, or storage in reservoirs, must be provided where hydro-electric schemes are installed to cover the period of low flow. In the circumstances, the best financial results *will be obtained by a joint power and irrigation project,* for it is out of the question to erect auxiliary plant for developing power during the dry season, owing to the high capital cost of two separate plants.

Development of Water Power from the Vaal River.

The provision of cheap motive power is one of the principal factors in the industrial progress of any country. The usual

manner of providing power is by the combustion of hydrocarbons, the principal of which is coal. In England alone it is estimated that 80 million tons of coal are consumed per annum in the production of power. For every horse power generated by water power there is a saving of about 13 tons of coal per annum, if 3 lbs. of coal are allowed per h.p. hour for a steam plant. Rain, including snow, is the source of all water power, and after it reaches the rivers it is available for power; but whether it is possible to utilise that power economically is a matter which can only be decided upon after carefully considering the amount of capital required and the cost per horse power year, as compared with the cost of production by other means. Many laymen, and even some engineers, are apt to conclude that water power costs nothing, or next to nothing; but this is a fallacy which only needs investigation to condemn it. Where cheap coal is obtainable it may prove much more economical to generate power from that mineral, and one of the finest object lessons in the Union is that of the Victoria Falls Power Company on the Rand. It was originally intended to generate water power *at the Victoria Falls*, but it was subsequently found that it would be much more economical to generate power from coal obtained from the Transvaal coalfields. In some cases it may, however, be found desirable to utilise water power, even at a high cost, owing to the price of coal being prohibitive.

Another factor to consider is the possibility of having to provide storage in a reservoir for generating power during the dry season, when very little water is flowing in the river, or, on the other hand, the necessity of installing auxiliary prime movers for generating power during dry periods. With large rivers it is not always necessary to provide storage; but with South African rivers it may be taken as an axiom that the generation of power direct from the river without storage during the dry season of the year is almost impossible, if it is desired to obtain a large amount of power during the whole year.

A Committee, known as the "Water Power Resources Committee," has been appointed by the Board of Trade (England) to investigate the water power resources of Great Britain, and this Committee has issued a preliminary report, which can be obtained on application to the Board of Trade.

It is estimated by the above Committee that the capital cost of installing hydro-electric schemes in Great Britain will be about £38.5 per effective electrical h.p. developed at the power stations if the post-war prices are taken as being 50 per cent. above pre-war prices. If, however, interest on capital is allowed during the construction of the works, the cost will be in the neighbourhood of £41 per E.H.P. The Committee also say that it will pay to instal hydro-electric stations in Great Britain if the cost of developing water power does not exceed £60 per effective electrical horse power for a station capable

of generating about 5,000 E.H.P.—the basis of comparison being a coal of 12,500 British thermal units at 10s. per ton delivered at the power station. The cost of generation with a 5,000 E.H.P. hydro-electric plant will be about 0.15 pence at the station with a properly designed plant, if the load factor is fairly high and the demand continuous throughout the 24 hours, and the total cost, including interest and redemption, may be taken at about 0.25d. per unit.

In Canada it is estimated that 90 per cent. of the total power generated is obtained from the rivers of the country. The average actual cost of the hydro-electric stations throughout Canada is about £38 per installed E.H.P., including power station plant, buildings, lands, transmission, and distribution systems, while the average number of employees (white) employed on the undertakings is 4.8 per 1,000 H.P. installed, and the wages paid amount to about £1 *per annum* per H.P. installed.

The cost of erecting a 5,000 E.H.P. *steam generating station* in South Africa, including land, buildings, plant, etc., at a central station may be taken at about £42 per horse power. The cost of transmission and distribution lines, transformers, sub-stations, etc., must be added to the above, and this will, of course, vary according to the length of the line, etc. The cost of generation at such a station in South Africa may be taken at about 0.2d. per unit, if a 12,000 B.T.U. coal is supplied at 9s. per ton. If interest and redemption is included, the cost may be taken at about 0.30d. per unit.

The cost of a hydro-electric plant in a selected position on the Vaal River would probably be about £35 per E.H.P., and the total cost of generation, including interest and redemption, 0.25d. Taking a basis of 0.25d. per unit, the cost would be £6 8s. per horse power year for continuous running.

The cost of hiring power per H.P. from large generating stations in the United States of America may be taken at from £2 10s. to £6 per annum, according to the nature of the load.

In Norway the cost per H.P. year is about £3 10s. for continuous running throughout the year.

TABLE G.

Principal Falls of the Vaal River.

Position.	Average Flow in Cusecs with Proper Storage.	Distance in Miles.	Total Fall in Feet.	Theoretical Horse Power.
Groothook Dam Site to Standerton Railway Bridge	700	42	178.6	14,200
Koppiesfontein to Engelbrecht's Drift	1,500	30.8	160.6	27,390
Engelbrecht's Drift	2,000	3.8	48	10,900
Lindeque to Parys	2,500	23.9	163	46,122
At Parys	do.	1.7	81	22,920
Lindeque Falls to De Wet's Drift	do.	57.8	370.3	104,780
Christiania to Windsorton Pont	do.	55	334	94,580
Fourteen Streams to Windsorton Pont	do.	21	232	65,646
Barkley West to Infall of Harts River	do.	24	283	80,078
		Total	H.P.	466,616

The above list shows that a large amount of power is available from the Vaal River, but owing to the long lengths of pipe line required to take advantage of the falls, it is impossible to say, without careful estimates being prepared, whether the schemes are financially sound or not. It is highly probable that hydro-electric schemes at Engelbrecht's Drift, Parys, and Fourteen Streams would be paying propositions; but without making proper surveys and estimates of the cost, no definite conclusion can be arrived at. The average flow of the river is given in the first column, and the total power is roughly estimated at 466,616 theoretical horse power, while the actual, after allowing for efficiency of plant, etc., will be about 300,000 horse power.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY, AND GEOGRAPHY.

President of the Section:—H. H. Green, D.Sc., F.C.S.

WEDNESDAY, JULY 9.

The President delivered the following address:—

MODERN CHEMISTRY.

One of the most characteristic features of the development of modern Chemistry is the steadily growing tendency to subdivide. Of recent years this tendency has been so marked that the various offspring of the mother science have taken on the aspects of new sciences, and the time has come when no chemist can lay claim to anything like a complete grasp of the subject to which he owes his name. This process of fission is inevitable and has its origin in the nature of the science itself. Being a basic science, like Mathematics and Physics, it enters into every department of human activity, and it has become a platitude to say that the chemist has all Nature for his province. Like Mathematics, the science might take for its ideal the compression of the Universe into an equation; with God, mayhap, as only arbitrary variable.

The field of Chemistry is so wide, and the mass of detail so enormous, that no single brain can hope to do more than grasp the underlying principles and methods of the science as a whole, and make itself master of a comparatively small corner. Specialisation has therefore proceeded, particularly in research, to an extraordinary extent; and the ramifications of the subject are so complicated that most people have only the haziest notion of the meaning of the word "chemist."

To the altogether uneducated, the term "chemist" is synonymous with that of "pharmacist" or "druggist," and, indeed, the vendors of stuffs in bottles, compounders of the decoctions prescribed by those skilled in the black art of medicine, have claimed the word for their own. Indeed, so far at one time did the term fix itself in common speech that it passed into legislative use, and, as Sir William Tilden points out, "if Sir Humphry Davy himself were now living he could not legally call himself a chemist, his name not being on the pharmaceutical register. Other lands are more discriminating in their speech—Germany using the word "apotheker," and France the word "pharmacien," as corresponding to our seldom-used "pharmacist." Far be it from any chemist mind to decry the calling of pharmacy. Properly qualified pharmacists are proud of the term, since it corresponds to a calling with a definitely recognised, legally protected diploma, and one in which it is now possible to take a university degree. Be it only

emphasised that it is more allied to the medical science of pharmacology than to the abstract science of pure Chemistry, whose devotees rarely happen to be qualified to take a place on the pharmaceutical register. It is as much to the interest of the pharmacist as of the chemist to separate the two terms. The confusion, however, will doubtless last a few years longer, although it involves bad English and worse sense.

To the somewhat better educated, a chemist means a man who "analyses things." This confusion is not quite so reprehensible, since analytical chemistry is a branch of Chemistry proper, and some dignity is graciously accorded to it—saving word "analytical," which, like the blessed word Mesopotamia in the Bible, has a fascination for some minds.

To the well-educated along old-fashioned lines, Chemistry is a science which they learned all about in their first year at college; something they have forgotten.

To the *properly* educated, Chemistry is a science underlying all knowledge of material things, and providing the armoury of all other sciences, professions, arts, and trades; is one of the three basic sciences of Natural Philosophy. In his introduction to that admirable series of essays, "Science and the Nation," issued by the Cambridge Press, Lord Moulton takes occasion to point out that "in such a presentation it was inevitable that Chemistry should take the first place."

The war has done much to open the conservative British mind, and the national importance of Chemistry is more clearly recognised. There is no doubt that a new era in dignity has dawned for the chemist, and that the significance of his work will quickly filter down to the voter and up to the politician. To the discriminating he has never lacked in dignity; nor even to the thoughtless, when he turned his science into trade and made tracks for the Upper House.

But to return to the fission of our science.

At the beginning of the last century Chemistry was divided into two main branches, "Inorganic," which dealt with metals and minerals, and "Organic," which concerned itself with compounds of animal or vegetable origin. In 1828 the famous research of Wöhler, resulting in the conversion of ammonium cyanate, which had been prepared from wholly inorganic sources, into urea, which had hitherto only been known as a product of vital action, smashed the arbitrary distinction between "organic" and "inorganic," and reunited the breaking science. The reunion, however, was of very brief duration, since in following up the ideas involved in the first organic synthesis it was found that the number of derivatives of the one element, Carbon, far exceeded all the other derivatives of all other elements put together, and it soon became evident that a fresh division into carbon and non-carbon compounds had to be made. Since Carbon was the most characteristic element of the old "organic compounds," the old term was revived, and "Organic Chemistry" became the "Chemistry of the Carbon Compounds." The

number of such compounds now actually described is somewhere about one hundred and fifty thousand, and new members are being added to the list every day. The number theoretically predictable is a question only of permutations.

Since they are of extraordinary complexity, no chemist, professed organic chemist though he be, makes the least attempt to remember, or deal with, anything more than a mere fraction of them: but contents himself with type compounds and a study of the underlying principles involved in their preparation or synthesis, the determination of their constitution, their sources, properties, and the uses to which they can be put. To attempt to memorise the way in which the constitution of them all has been determined would be as stupid as to attempt to memorise a few thousand games of chess. Obviously, it is only possible to learn the principles of the game.

The domain of the organic chemist is so wide, and the problems he may have to tackle are so intricate, that the modern investigator usually finds it necessary to confine himself to a very small section of his branch science; ogle the amino-acids, give his heart to a heterocyclic ring, or soak his brain in an aniline dye. But if he does any of these things he becomes a very useful person.

As an illustration of the significance of Organic Chemistry in our daily affairs, the chemistry of coal-tar may be taken.

In the early days of coal-distillation the only products arrived at were illuminating gas and coke, the bye-product, tar, being regarded as of little value. Various chemists then took up the study of coal-tar, at first in the spirit of "pure research," and at the present day the commercial value of the tar products far exceeds that of the illuminating gas itself. These products are so numerous and so important that it is impossible to offer even the briefest sketch of them here. Suffice it that huge industries have arisen from the first academic researches, and that the products go to feed all the other arts and sciences. To the doctor go his anæsthetics, his hypnotics, his febrifuges, and his specific drugs like salvarsan; to the biologist his stains and solvents, and to the dyer his dyes; to the soldier his explosives; to the photographer his developers; to everyone, directly or indirectly, something. It would be difficult to estimate the value to the community of the labours of the early organic chemists, to whom the coal-tar industry owes its origin, though some idea of it may be obtained when it is considered that before the war Germany exported over ten million pounds' worth of coal-tar dyes alone per annum. It may not, perhaps, come amiss to point out that the first step in the sequence of development was made in Britain in 1856, when Sir W. H. Perkin, then a boy of eighteen, was carrying out a research with a totally different object in view—a research into Quinine. In the course of his work he obtained a substance which "seemed worthy of further investigation." Being a scientist and not a utilitarian, he did not throw it away, but instituted

further research. It turned out to be a dye-stuff, "Aniline Mauve," or "Tyrian Purple." Further investigation paved the way for similar synthetic products. This came just at a time when the chemistry of coal-tar was being developed, and since Benzene was the basis of Perkin's dye, the way was clear for the commercial exploitation of his discoveries. Indeed, the youthful Perkin turned sufficiently utilitarian to start a factory at Greenford Green, although his heart was always in research, and in 1874, at the age of 36, he retired from business as a manufacturer to devote himself exclusively to the pursuit of knowledge for its own sake. It is of interest to remember that until 1870 Perkin's works were the only producers of artificial Alizarin.

At the time of Perkin's discoveries Britain was the greatest producer of coal-tar, and was pre-eminent in the dyeing industry. Six years after the discovery of "Aniline Mauve," Hofmann, a a German, wrote in his report on the London Exhibition of 1862:—

"England will, beyond question, at no distant date, become herself the greatest colour-producing country in the world; nay, by the strangest of revolutions, she may, ere long, send her coal-derived blues to indigo-growing India, her tar-distilled crimsons to cochineal-producing Mexico, and her fossil substitutes for quercitron and safflower to China, Japan, and other countries whence these articles are now derived."

It may well be asked why English manufacturers, with exhibits in frames under their noses, and prophecies such as Hofmann's before them, did not avail themselves of their opportunities, and why England has fallen from her premier position in the world of chemical industry. Two causes for the decline are apparent: firstly, the neglect of organic chemistry in the Universities, and, secondly, the total indifference of manufacturers to the practice of research in connection with their own processes. The period belonged to the dark ages of compulsory Greek, when the Professor of Chemistry at Cambridge was a country clergyman, who nobly came up once a year to give a course of lectures; when, as Tilden remarks, it was thought very creditable on his part to do so much.

Perkin himself, Meldola, Green, and numerous other English chemists, raised their voices in vain against the national neglect of chemistry. The neglect continued, and by the early eighties Germany had gained control of the infant industry. And not only of this industry, for the highly trained research chemists engaged in the laboratory investigation on synthetic dyes developed other lines of research, so that on the outbreak of war Germany had practically the whole trade of the "fine chemicals" (highly priced, finished products) in her hands: a trade so vast that the *export value* was estimated by Professor Grossman, of Berlin, at *ninety-seven and a half million pounds per annum.*

Fortunately, the day of neglect is well-nigh over in Britain, and there is a chance that part, at least, of the trade in dye-stuffs

and fine chemicals will "come home." Shortly after the outbreak of war, when the dye-houses of Yorkshire and Lancashire were almost at a standstill, and a textile industry worth 200 million pounds per annum was embarrassed for the lack of about one million pounds' worth of dye-stuffs, the Government assigned a million sterling to an attempt to resuscitate the production of synthetic dyes, and to provision for research into the making of colours from coal-tar hydrocarbons. Further large endowments for general research are promised, and it is being recognized that "scientific research" is a matter for the State as well as for private enterprise. It may be mentioned in passing that the *natural indigo* industry is not necessarily past redemption. Germany's export trade in synthetic indigo rose to about two million sterling in 1913, while the area under cultivation of indigo in India fell from one and a half million acres in 1897 to less than a quarter of a million acres in 1913. But it is not impossible that a little money spent on chemical and botanical research in relation to agriculture might turn the tide, and put the natural indigo in the position to smash up the synthetic industry. It must not be forgotten how Germany built up her trade in sugar from beet, and the important part played by the breeding of high-sugar roots, and the utilisation of waste products of the sugar factories.

Leaving now the domain of Organic Chemistry, we may consider Inorganic Chemistry, or the chemistry of the non-carbon compounds. This branch of chemistry is also an enormously wide one, and concerns an enormous number of compounds—all the compounds of some ninty odd elements. Every chemist must, of course, have a thorough grounding in inorganic chemistry; but, again, no modern chemist professes to cover in detail the whole field. The modern investigator or practitioner finds it necessary to limit himself, after his broad general training in all branches of chemistry, to some one section. He may, for instance, devote his attention to the chemistry of metals, and become a "metallurgist"; to that of minerals, and become a "mineral chemist," or to any other section, and label himself with an appropriate name. Inorganic chemical processes underlie so many of our industries that it is impossible to enumerate them here; the production of the metals, including gold; of steel and special alloys; of the gigantic alkali and acid requirements; of artificial manures; of incandescent mantles; of a thousand and one articles of every-day use.

The third big sub-division of Chemistry is "Physical Chemistry," a section of the science overlapping into physics. It includes what is termed "chemical statics" and "chemical dynamics," and the relationship between chemical properties and physical properties; position of equilibria in chemical reaction, speed of chemical reaction, and influence of mass as well as of chemical structure of reacting materials, optical and electrical properties of substances, ultimate constitution of matter, and so forth. It lies at the root of all chemical theory, whatever

branch of chemistry be considered. The Haber process, upon which Germany depended for her nitrogen supply during the war, is a technical triumph of physical chemistry.

Physical Chemistry is, again, a section so wide, that although in the sense now used it is a product of the last quarter of a century, it is itself rapidly undergoing division. The separate science of "radio-activity" has already split off as a fission-product of very recent growth, but which in the last few years has contributed enormously to basic chemical theory and an understanding of the ultimate constitution of matter, and which is rapidly assuming great practical importance. "Metallography" is a section of physical chemistry which can also be treated as a branch of Metallurgy. It deals with the relation of the micro-structure of metals and their alloys, to their physical properties. It is a very young science, but it is already of enormous industrial importance. One of its recent achievements is the production, for aeroplane purposes, of an alloy which, weight for weight, is more than twice as strong as steel. Other fission-products of physical chemistry are rapidly developing, and it will not be long before "Colloidal Chemistry" attains the dignity of a separate science.

These three main sections, Inorganic, Organic, and Physical, represent the three primary lines of cleavage of the science of Chemistry. Analytical Chemistry, though to some extent it is taught as a separate science, and is practised as a separate profession, can hardly be called a distinct section of chemistry, since every chemist must be an analyst, and every analyst entitled to the name must be a sound general chemist with a training in all three sections of his science.

For Chemistry as a whole the sister science of Physics is absolutely essential, as also a working knowledge of Mathematics. For the higher reaches of Physical Chemistry the investigator must be a mathematician of no mean order.

These three major branches of chemistry are taught by separate professors in all properly equipped colleges, with sub-sections taught either by separate professors or by specialist lecturers, according to the purpose for which the institution exists, and its financial resources. Thus in the University of Illinois the chemical department proper is organised under seven divisions, with the following staff:—

General Chemistry and Qualitative Analysis.

1 Professor.	3 Instructors.
1 Assistant Professor.	8 Assistants.
1 Associate.	19 Graduate Assistants.

Quantitative Analysis and Food Chemistry.

1 Assistant Professor.	1 Instructor.
1 Associate.	7 Assistants.

Organic Chemistry.

1 Professor.	3 Assistants.
1 Assistant Professor.	1 Graduate Assistant.
1 Instructor.	

Physical Chemistry and Electro-Chemistry

1 Professor.	1 Instructor.
1 Associate.	1 Assistant.

Physiological Chemistry.

1 Professor.	1 Assistant.
1 Lecturer.	

Industrial Chemistry.

1 Professor.	1 Instructor.
1 Assistant Professor.	1 Assistant.

Water Analysis and Sanitary Chemistry.

1 Professor.	1 Instructor.

In addition to this staff of 60, there are 2 research assistants, 6 fellows, several graduate scholars, 1 glass-blower, 1 mechanician, 1 clerk, 2 stenographers, 1 lecture assistant, 4 storekeepers and laboratory helpers.

This, it may be further added, is only the general chemical department proper, and does not include the chemical staff of applied departments, such as the Faculty of Agriculture, which has its own professors and lecturers.

The Chemical Department of the Imperial College of Science and Technology, South Kensington, London, is staffed as follows:—

1 Professor of General Chemistry.
1 Professor of Organic Chemistry.
1 Professor of Physical Chemistry.
1 Assistant Professor.
1 Lecturer.
5 Demonstrators.
4 Assistant Demonstrators.
1 Research Assistant.
1 Professor of Chemical Technology.
1 Associate Professor.
1 Lecturer in Chemical Engineering.
1 Lecturer on Refractory Materials.
2 Demonstrators.

This, again, is the department of chemistry proper, and does not include Metallurgy, which has a department of its own, or Biochemistry, which is attached to a different department of the College.

The elaborate staffs shown here, merely for the teaching of one subject in its main aspects, give an indication of the way

in which the division of the science has proceeded. It may be added that applied departments, which take their title from the "group course" they teach, frequently appoint their own chemists separate from the department of chemistry proper. Thus the Medical Faculty in the Univeristy of Edinburgh has just appointed a professor of "Medical Chemistry," whose duty it will presumably be to arrange a compact course specially arranged for medical requirements. The University of Glasgow has just created a chair of "Physiological Chemistry," in which a section of chemistry will be taught as applied to general Biology—for students of medicine, pure science, and chemical technology.

Faculties of Agriculture also have their own professors of "Agricultural Chemistry," and in big American centres sub-sections, such as "soil chemistry," "dairy chemistry," and so forth, are handled by specialist lecturers.

This reference to specialisation in chemistry, in directions other than sub-sections of the pure science, brings us to the second aspect of the process of fission.

It will be quite obvious by this time that there is no such thing as the "Compleat Chemist." The chemist has all Nature for his province, and all Nature is too big a morsel for mortal man to chew. Fission is inherent in the nature of the science and cannot be avoided, and when it gets down to bed-rock it is the specialised man nowadays who does the really scientific work.

Knowing this, it might be imagined that the science must of necessity drift to a specialisation so intense that its own broad problems suffer neglect; that the individual worker could never remain broad enough to visualise the main outlines of the practical application of his own subject; that he would not see the wood for the trees. This idea, however, is altogether erroneous, although it may perhaps have something to do with the pre-war British idea that the scientific specialist should be subordinate to the man of "broad" training, guaranteed to absorb the wood as a whole, and resolutely refuse to believe in the existence of the trees; guaranteed to fulfil the Euclidean conception of a plane—length and breadth without depth. It has taken a world-war to make the politico-legal mind realise that the very process of specialisation gives a fresh kind of breadth; a capacity for focussing details to a specific end. The English organic chemists, monomaniacs moaning over the constitution of the benzene ring, cried in the wilderness for 40 years before their country woke up to the fact that vital industries turned upon the question as to whether Kekulé, Claus, Ladenburg, or Armstrong, had been right in their conjectures concerning the configuration of the aromatic nucleus. In the hour of tribulation many men, "finding out" as Moulton described Pope, "how in the extremely quiet and domestic circle of crystals the various molecules sat round the table," were called in to remedy the neglect of half a century. That, it may be added

parenthetically, is the modest even-tempered genius of English administration—the capacity to rectify her blunders at the eleventh hour . . . even if she has to call an occasional Welshman or Scotchman to the rescue!

It must therefore (irrespective of the parenthesis!) be emphasised that the movement towards specialisation in chemistry is only one side of the question of "broad outlines" and "practical propositions." In the very process of specialisation chemistry is widening its sphere of usefulness, throwing out tentacles to grasp a whole range of subjects, which were formerly regarded as quite beyond the sphere of chemical handling, and which even yet only the chemist recognises as belonging to his proper province. It is true that it is rapidly becoming fashionable for every institution to have its "own chemist," but it is not so sure that every institution knows what to do with him when it's got him. At the present moment administrative departmental heads are in process of catching tartars—troublesome people who insist upon having a "different kind" of breadth of outlook, and want to do things which look very unremunerative.

To illustrate the way in which the highly specialised science throws out its tentacles to the other sciences and broadens the outlook of civilisation, a few concrete examples may be taken. Going first to the subject of Astronomy, which to the non-scientific mind would appear to be as untainted of chemistry as could be desired, a connecting link is at once provided by physical chemistry and its spectroscope, by means of which it is possible to analyse substances which cannot be handled, but from which light is available, and by means of which it is possible to do such odd things as calculate the speed of a star.

When a beam of complex light is passed through the prism of a spectroscope the light waves are differentially diffracted, so that each wave-length can be examined separately. The range of the rainbow colours in the visible spectrum corresponds to wave-lengths of one hundred-thousandth part of an inch at the violet end, to three hundred-thousandths of an inch at the red end, but since the range of wave-lengths capable of affecting silver salts is wider than that to which the human eye is sensitive, it is possible to photograph the ultra-violet or "invisible light," and so extend the range of spectroscopic analysis. Spectroscopic examination of a substance may be direct, by its so-called "emission spectrum," or indirect, by its so-called "absorption spectrum," *i.e.*, the spectrum obtained by allowing light which produces a continuous spectrum to pass through the substance to be examined before entering the spectroscope. In the former case a series of spectral bands, of colour if the wave-lengths all fall within the range of the eye, is obtained. In the latter a series of black "absorption bands," characteristic of the substance, is produced. Each element, in the condition of vapour, has its own characteristic spectrum,

and since the spectra of the known elements are known, it is possible to identify the lines of characteristic elements present in bodies emitting light of their own, or present in vapours through which light passes. The delicacy of spectroscopic analysis is very great, and it is possible, for instance, to detect one part of sodium vapour in twenty thousand million parts of air.

By turning the telescopic spectroscope on to the stars it has been shown that, although most of the well-known elements are there, some elements are present (unknown bands) which have not yet been discovered on the Earth, and have never been handled in our laboratories. The element Helium, which has recently become of great theoretical importance, and will be of great economic importance if it can be obtained in sufficient quantity, was first detected in the sun and actually named before it was discovered on the Earth. By studying the absorption bands in the solar spectrum the atmosphere of the Sun has been studied, and the presence of about 40 terrestial elements discovered.

By applying the telescopic spectroscope in another way it is possible to determine a "velocity" instead of a substance, and to determine the speed of stars moving in the line of sight. This is done by accurately comparing the position of certain lines produced by elements in the star with the position of the lines produced by the same elements in the neighbourhood of the spectroscope. Thus, for instance, if the hydrogen or iron line of a star is nearer the violet end of the spectrum than it should be, the star is coming towards us; if nearer the red end, the star is travelling away from us. By photographing stellar and terrestrial spectra of the same element on the same plate, and measuring the deviation with a microscope, it is possible to calculate the approximate speed at which Star and Earth are approaching to, or receding from, each other.

What is really being done is to measure the frequency of the waves of light from the star, since the position of any line in the spectrum is conditioned by this. A rough analogy which has been used to explain the process to the lay mind, is offered by the consideration of a person standing on the seashore with the waves breaking over his feet at a steady rate—so many per minute. If he now walks into the sea, he will encounter more waves per minute, and the faster he moves the more frequently will the waves appear to break over him. If he then walks back to the shore, the waves will appear to come more slowly and fewer will break over him in any given time. In reality the waves are coming at the same rate all the time, but by measuring the frequency with which they appear to come to him he could calculate the rate at which he was walking. In the same way, by measuring the deviation of frequency of the light waves coming from a particular element in a star, from the known frequency on the Earth, or, in other words, measuring the displacement of its spectral lines, the speed of the star in the line of sight can be calculated.

It may be mentioned, as of local personal interest, that Dr. Lunt, of the Cape Observatory, is a chemist turned astronomer, lured first by the connecting link of the spectroscope. Mr. H. E. Wood, of the Johannesburg Observatory, one of our vice-presidents last year, is a physicist turned astronomer.

As an illustration of the application of Chemistry to Geology, the work of van 't Hoff on the salt deposits at Stassfort, East Prussia, may be cited. These salt beds, best known from their enormous economic importance as major source of the world's supply of Potash, have been shown, largely by chemico-geological methods, to have been formed by the gradual drying up of an inland sea, the various salts now found being deposited at varying temperature and concentration in accordance with the laws governing ionic equilibrium in solution. Van 't Hoff, from the elaborate data acquired in his work on the chemical compounds occurring in the Stassfort beds, was able to show that certain of these were only capable of simultaneous deposition within narrow limits of temperature. Thus from the presence of Glauber's salt and Astrakanite in the same stratum, he could fix the temperature at which that stratum was laid down as between 4.5°C and 18°C. Other sensitive compounds defined still narrower limits, in some cases giving upper and lower ranges to within half a degree, and by skilful interpretation of chemical data it became possible to determine very accurately the actual temperatures, and nature of seasonal variation, under which the various strata were deposited; thus affording invaluable information to the geologist concerning conditions maintaining millions of years ago. As for the present day, the utilisation of these beds, with their output of thirteen million tons of potash salts per annum, demands the services of the trained chemist at every turn, while the ramifications of the industries dependent upon them brings in highly specialised sections of chemistry in all directions. Their use in agriculture has been associated with the budding of pure chemistry into "agricultural chemistry"—in which connection it may be pointed out that far and away the greater part of the basic work upon which scientific agriculture turns, is due to chemists and botanists who succumbed to the fission of their sciences.

The development of Agricultural Science is too long a story to tell here, but the dominant part played by chemists is reflected in the personnel of institutions devoted to agricultural research. At Rothamsted, for instance, the succession of directors has been a succession of able chemists. That, in the opinion of competent agricultural authorities, specialisation in applied sciences should still follow the natural cleavage line of fission from the pure sciences, is clearly indicated by the recent "Memorandum on the Reconstruction of Agricultural Education in England and Wales," published by the Agrciultural Education Association. Paragraph 65 runs: "For the 'scientific specialist' class

of student we would recommend the Honours Degree courses in pure science, rather than the agricultural degree course, as the normal avenue of approach to specialisation, with the addition of a post-graduate course in agricultural science. The agricultural degree course may be made to serve as preliminary training for specialisation, though *not as satisfactorily,* if *supplemented* for this purpose by a full post-graduate course of Honours' standard in pure science. One year's practical training on a farm is a most desirable part of the education of such a specialist."

It may be added that for general agriculturalists, such as county advisers, non-specialised teachers, and those following general agriculture as a profession, the reverse mode of education is regarded as satisfactory; a general diploma or degree course, embodying the general applications of the sciences.

This emphasis on "pure science first," for the research worker, is a hopeful sign for education; is presumably made with the idea of inculcating the *method and principles* of science before allowing the student mind to be fuddled in the cloud of empiricism, which of dire necessity is associated with practice; the specific object in view being to ensure a "scientific" rather than a "professional" cast of thought. Each man to his trade. In the past, the progress of research has suffered much from the methods of the Jacks of all Sciences, whose work too often was not sufficiently fundamental to stand the test of time.

Agricultural chemistry is itself rapidly undergoing fission into specialised sections connected dominantly with some one or other branch of agriculture.

In regard to the science of Physiology the points of contact with chemistry, more particularly with physical chemistry, are so numerous that one can hardly venture to begin upon them. All the methods for the study of vital processes are either physical or chemical at bottom, and indeed Huxley defined the position of Physiological Science as "midway between the physico-chemical and the social sciences." Physiology itself divides naturally into two sections, "general" and "comparative." The latter is largely a descriptive science, dealing with the mechanism of living structures, and merges into morphology and anatomy. General Physiology is much more fundamental, and deals with the way the mechanism works; deals more with the underlying interpretation of physiological phenomena, than with the simple description of functions. It is therefore the side upon which Chemistry most naturally joins forces. The borderline science of "Physiological Chemistry" has been singularly fruitful in recent years, and though its independent status is but recently acquired it now carries its own department, and usually its own professorship, in progressive universities. The somewhat wider term "Biochemistry" is usually used as synonymous with "Physiological Chemistry," but as the term signifies the "chemistry of life" its scope is so wide that still further fission

is under way. On the botanical side it is rapidly developing the independent off-shoot "Phytochemistry." The various branches of agricultural chemistry, except in so far as they are purely analytical, also come under the biochemical group, and require a working knowledge of one or more of the biological sciences.

The science of Bacteriology, founded on a scientific basis by the famous French chemist Pasteur, is an off-shoot of chemistry which has long since attained its independent status, and although still little more than a fusion product of Chemistry and Botany in so far as pure Bacteriology, Agricultural Bacteriology, and Industrial Bacteriology, are concerned, its importance in human medicine has tended to associate it in the popular mind with Pathology. The general medical bacteriologist, however, is rarely a chemist, and since the days of Pasteur pure Bacteriology has suffered much from too close an association with Pathology. The modern Universities are now separating the two subjects.

A new borderline between Chemistry and Pathology is fast attaining importance, and progressive institutions, such as St. Thomas's Hospital in London, have independent lecturers on Chemical Pathology.

Where the chemist takes to Medicine we get fresh borderlines developed; as in the case of Ehrlich, who was chemist first and medico afterwards, and did so much for the development of immuno-chemistry. It is interesting to note that the famous "side-chain" theory of immunity is a direct analogy from organic chemistry, and that although it has well served its day the future development of immuno-chemistry promises to turn on the chemistry of colloids.

It may be added that Professor Ehrlich was also the pioneer in the new line of "chemotherapy," a borderline between chemistry and therapeutics. Since this is of popular as well as of purely scientific interest, an illustration may be taken of the ultimate fashion in which the discovery of new remedies in medicine depends upon combination of chemcial and physiological knowledge. "Salvarsan," "606," the notoriety of which has spread to the populace on account of its use in curing the social scourge of syphilis, offers one of the best examples. The problem before Ehrlich, when he embarked upon his researches, was to obtain a poison which, when injected into the blood-stream, would destroy disease-producing organisms without affecting the tissues of the body, *i.e.*, to prepare a *selective* drug. At first sight such a problem appears to be too complicated for solution, but the analogy of the dyeing vat came to the rescue. It was well known that certain dyes which would give a "fast colour" with silk would not do so with cotton, and the same principle applied to the selective staining of bacteria and tissues, was already giving fruitful results in biology. It was also empirically known that

compounds of Mercury were useful in the treatment of syphilis, although the causal organism (*Treponema pallidum*) of the disease had not yet been discovered. Unfortunately, however, Mercury compounds could not be used in adequate amount owing to their poisonous action on the patient, and the problem became one of getting the mercury into a dye-like compound, which would be selectively fixed by the organism without killing the patient; in other words, to "cover" the mercury with chemical groupings for which the causal organisms had a special affinity, but for which the tissues of the body had not. It was soon found, however, that dye-mercury compounds were unstable in the body, and that the mercury was too easily set free again in a form poisonous for the subject. The next problem was to find a substitute for mercury which could be effectively "covered" in such a way as to combine a harmless grouping for which the disease organism had some special affinity, with a toxic group which would kill it. The element arsenic seemed promising, and Ehrlich, in colloboration with others, finally succeeded in preparing the compound "Salvarsan," the chemical name for which is 3:3′–diamino–4:4′—dihydroxyarsenobenzene-dihydrochloride. Only the expert chemist can realise the enormous amount of labour and ingenuity expended in the research which culminated so brilliantly; involving, as it did, the devising of methods for synthesising unknown organic derivatives of arsenic, and the elaborate testing of the new compounds. But some idea of the labour involved is indicated by its laboratory nick-name "606"—success came only after the six hundred and sixth compound was prepared. Further researches, along similar lines, for specifics against bacteria, spirochætes, and trypanosomes, are now in progress all over the world, and it seems probable that a new era has been heralded in the long combat against disease. But the practitioner must not expect immediate results. The number of compounds of the class under consideration is rapidly going up into the thousands, but the chase is a long one. One of the most recent derivatives, "Margol" or "102," is a complex organic compound of arsenic, antimony, and silver, and is claimed to be superior to Salvarsan for the treatment of Syphilis. As the connection between chemical constitution and physiological action becomes gradually worked out by the pure sciences, fresh lines of application to medicine will suggest themselves.

It would take us too far off the main track of the ramificatoins of chemistry to go into other subdivisions of the borderline science of biochemistry.

On the industrial side, it may be mentioned that subjects such as Brewing are dominantly biochemical, and that the director of the school of Brewing in the University of Birmingham is a biochemist of the first order, who has turned out work of fundamental interest to the science. In Birmingham University a diploma in Brewing is granted to students taking a three-

year course, while a degree course in the Biochemistry of Fermentation is provided for students who intend to devote themselves to the upper reaches of their subject. It may be added that the whole progress of brewing, from the time of Pasteur onwards, has been a chemist's progress.

In regard to the industrial ramifications of chemistry, space forbids further mention. Suffice it that there is no industry into which the chemist has not penetrated, and many industries depend for their whole existence upon some basic chemical discovery or continued chemical control. Thus the development of the whole mining industry of the Witwatersrand, and the very coming into existence of the city of Johannesburg, was conditioned by a laboratory observation made originally by a pure chemist, and developed by a mineralogical chemist—who, it may be added, did not get enough out of his patent to enable him to abandon his practice. The cyanide process for the extraction of gold from low-grade ores and tailings makes just that difference between profitable and unprofitable production of gold in South Africa, and without it the industries of the Witwatersrand would never have reached their present development.

In the application of his science to the industries the chemist has three lines of activity. He may be asked to control the technical aspects of the industry entirely, owing to the fact that they are so dominantly chemical as to make "fool-proof" methods impossible of application. Or he may be asked to step in and subject an existing empirical process to scientific study, and devise methods whereby it may be improved. Or he may be asked to discover a totally new method of carrying out some desired operation, the need for which is obvious, and upon which an industry is to be built up. Of this last line we may take as examples the problem of the commercial utilisation of atmospheric nitrogen, and of the preparation of synthetic rubber. The atmospheric nitrogen problem was still in the hands of the theorists 18 years ago. At the present day it has been solved in several different ways, and millions of pounds worth of nitrate and ammonium compounds are produced per annum. Had it not been for the processes discovered shortly before the war Germany would have been beaten before 1915 was out, since she was completely cut off from the natural sources of nitrogen previously used for explosives. In this connection the words of Lord Moulton at the last annual dinner of the Chemical Society in London, are of interest:—

"Few people, I think, realised the extent to which this war was based on chemists and chemical progress. There is not the slightest doubt that the dogs of war were held in leash until the completion of those great installations which produced ammonia by the Haber process. Germany was wise enough to realise that she must not be cut off from her nitrates unless she could produce at home ammonia in the vast quantities required

for the nitric acid for explosives, and she waited until the magnificent installations were completed by which she could attain this end. That was not all. The Germans knew that this war would be a war on an enormous scale, utterly deceived as they were as to the length of time during which it would last, and they looked to the large chemical installations for the manufacture of dyes and other chemical products to be the source of the munitions necessary to carry on the war."

But the fact that the solution of the problem of fixation of atmospheric nitrogen made war possible for the Central Powers must not be allowed undue prominence. The problem was not solved with that end in view. Rather let us hope that chemistry will make war altogether impossible before another war-broth has time to brew, and dwell upon the other side of the picture of nitrogen-fixation; turn our eyes rather to spectacles like that of Saaheim in Norway, which was transformed from a little village of 50 poverty-stricken farmers in 1903 into a prosperous town of six thousand inhabitants in 1913. Britain alone imported one and a half million pounds worth of Chili nitrate per annum in times of peace, and used still more nitrogen in other forms—herself producing nearly half a million tons of ammonium sulphate per annum from coal.

The peaceful operation of fertilising the soil is one of the largest outlets for combined nitrogen, and the significance for the world of the conversion of "air and water-power" into nitrate is incalculable.

The second illustration we have selected of the importance of "Industrial Chemistry," concerns the future. The labours of the pure organic chemists on the synthesis of rubber are not yet over, as the applications for patents show, but synthetic rubber has been produced by several methods, such as the action of Sodium on the hydrocarbons Isoprene and Butadiene. The starting point for the preparation of Butadiene is Butyl Alcohol which in turn is produced from Starch by the action of a microorganism—another leaf which can be added to the laurel-wreath of Biochemistry. One of the other products of the same fermentation of starch is Acetone, a solvent much used in the making of explosives, and for which Britain was in temporary desperation shortly after the outbreak of war. To the glory of our science that desperation was only temporary.

But the peaceful production of rubber from "potatoes and salt" is not yet a commercial proposition. The rubber is superior in some respects to natural rubber, but the technical difficulties in the way of the synthetic process are still too great to allow of commercial success, so that the shareholders in rubber plantations need have no immediate fear of bankruptcy. Fortunately for them, scientific research takes time, and the cheap synthetic rubber which is destined to pave our city streets, is likely to come on to the market so slowly as to give ample time

for the plantation areas to turn to providing nutriment for those tramping over the synthetic enemy.

So much, then, for the ramifications of chemistry, that most basic of sciences (*pace* sister Physics and brother Mathematics), pursued for her own sake by the pundit, cultivated for ulterior motives by the worldly-minded (*pace* all sensible people); life-time study for her devotees, first-year nuisance for the practising professions (*pace* Mr. Doctorman, member not of the "oldest profession in the world," but of the one with the strongest trade-union).

These ramifications of the science have only been touched upon, but should suffice to show the fashion in which the pure science is throwing out tentacles to other sciences; itself suffering fission and then conjugation; narrowing by specialisation and widening by encroachment. On the one side the science has an Octopus aspect; on the other it suggests the primordial protoplasm of the evolutionary tree. It must have been the Octopus aspect which appalled Mr. Warington Smythe when, in a witty comment upon Dr. Juritz's presidential address last year, he murmured, "What a miserable worm every one of us who is not a chemist must feel!" But it is the protoplasmic activity of the science which concerns the world.

It has been shown that specialisation in Chemistry is inevitable; that there is no such thing as the "compleat chymyst" as there was a century ago, when all that was known could come within the compass of a single brain, and the principles involved were easily grasped.

Remains then the question of how to educate the specialists. In the past this question has been allowed to settle itself, and the borderlines of sciences were left to individual enterprise. The exponent of one science was left to overlap into another as curiosity, fate, or gambling instinct, led.

The pure chemist passed into applied chemistry by following a point of contact with another science, and then becoming a master of the new field. One of the foremost agricultural chemists of the present day was a pure chemist, who became interested in the borderline by the cultivation of roses. Other agricultural chemists, men who have built up the science, are such by decree of fate; happened to get jobs which brought them into contact with agriculture, and compelled the acquiring of the requisite knowledge of that subject.

In the Industries the pure chemist of the older generation suffered metamorphosis into the industrial chemist by the necessity for grasping the essentials of an industry which he was called upon to help. Very often downright cupidity was the motive power, and cases are not uncommon of a pure chemist patenting an idea and then turning manufacturer in order to exploit it. In transition he had frequently to develop into a very presentable engineer. Sometimes the hybrid resulted from the manufacturer turning chemist, but this was less frequent

owing to the basic nature of chemistry itself, and was generally only successful when the chemistry demanded was of a comparatively simple order. One can, for instance, hardly imagine a manufacturer of rubber goods turning chemist and discovering synthetic rubber, whereas it requires no stretch of imagination at all to visualise the chemist switching from the small scale to the large scale and turning manufacturer. Our modern millionaire chemists, like Sir George Beilby, are examples.

The chemists who crossed the borderline, not into industry but into other pure sciences, were men actuated chiefly by the simple love of research, and who saw there profitable fields for fresh discovery and "scientific reputation." A borderline science "in process of becoming" is always a fruitful field for the enquiring spirit, tired of the beaten track, and relatively careless of gain. And of such is the Kingdom of Science. Fortunately for the world's progress, man's rise from the beasts has bred a big sprinkling, who care more for high thinking than high living, and who are satisfied with a competency and an intellectual life. For the benefit of our national administrators let us hasten to emphasise that there is no fundamental incompatibility between high thinking and high living; that the world's masterpieces of art were painted on pork-chops, and that even the purest of scientific palates can appreciate a little sherry in the trifle!

In the border-lines between two pure sciences it frequently happened that men came over into the new territory from both sides. Thus in that branch of Biochemistry which lies at the junction of Chemistry and Physiology, and is still young, chemists have gone over into Physiology, and physiologists come over into Chemistry; becoming then "Physiological Chemists" or "Chemical Physiologists," according to their starting-points or their bias. Although the investigating temperament is not one which depends upon its past academic education for its knowledge throughout life, but is student all its days, it is still true that the early bias tends to reflect itself in all the subsequent work of the investigator, and early training is a matter of no small importance.

The best work is frequently accomplished by collaboration between different investigators crossing into the same territory from different sciences. Each then brings the specialised technique, ideas, and cast of mind, characteristic of his own science. Sound collaboration between equals is the best way of developing new sciences or of applying old sciences to new problems. The very prejudices of each science can then be turned to account—flint striking on flint generating the sparks of truth.

So long, then, as any science is in its infancy, it can only have one mode of development—fission from existing sciences. Orthodox training is not yet provided, and the science is dependent wholly upon private enterprise; upon "foreign adventurers," of whom any country may be justly proud. As

soon, however, as development is advanced, and the demand for students of the new science is created, it is possible to arrange specifically for their training, and to offer one or more definite professional courses for the coming generation. This is what has happened in the case of the best-known "orthodox" professions and professional applied sciences. Time was when the apothecary plied the bleeding-cup and saw, and was physician and surgeon of his day. That day is long past, and once the medical profession established itself, and arranged its professional training, it soon succeeded, in virtue of the supreme importance attached by even the highest in the land to their own skins, in forming a closed ring and keeping out the layman. Time also was when the veterinarian was the local farrier. That time, too, is gone, although it is only within recent years that the calling has won into the ranks of the clearly defined professions and claimed its knighthoods for services rendered to the community. The passing of "general practice" and the increasing significance of the veterinarian in matters of "State Hygiene," is bringing the profession daily into greater prominence. It has a clearly defined four years' college training for diploma purposes, any specialised training which the more scientifically-minded are disposed to undertake being left to the science faculties of other institutions, or to post graduate study.

So also with dentistry, a profession which is fast passing out of the hands of the merely muscular into the hands of qualified and scientifically trained men.

So also with other orthodox callings. As soon as the demand for a stereotyped general training becomes great enough, it is met by organised teaching institutions. Industrial Chemistry and Chemical Engineering now belong to that group. The Charlottenburg Institute in Berlin offers a seven years' course (D.Ing.) in Industrial Chemistry. Most of the British technical Institutions offer a four years' course, leaving the student to develop his profession further in actual contact with the particular industry into which he passes, or to undertake specialisation by post-graduate study.

The practising profession of "Analytical Chemistry," and the various requirements of the "consulting chemist," are likewise met by orthodox curricula. In the nature of the profession, however, the analytical chemist tends to rapid specialisation, and this is recognised by the Institute of Chemistry, which, although it demands a sound knowledge of general chemistry in its intermediate examination, allows of specialisation in its final, and demands special knowledge of one of seven groups: (*a*) Mineral Chemistry, (*b*) Metallurgical Chemistry, (*c*) Physical Chemistry, (*d*) Organic Chemistry, (*e*) Chemistry and Microscopy of Food and Drugs, Fertilisers and Feeding Stuffs, Soils, Water, etc.; including the chemical-legal aspects of the group, (*f*) Biological Chemistry and Bacteriology, (*g*) Chemical Technology.

Analytical Chemistry can, of course, be treated as a separate

science, but as a practising profession it is more orthodox, and serves some definite social function or some defined State purpose, like the calling of the unspecialised medical practitioner. Unlike medicine, unfortunately, its major activities are not a matter of human life and death, and it is, therefore, much more difficult to exclude the "quack." The sphere of the analyst is too wide to allow of State specification of his functions. The State cannot interfere with a "fellow who wants to analyse things," or with one who fancies himself as a consulting chemist. All it can do is to take care that he is not allowed to do State work without recognised qualifications. This it does do—Government, County, and Municipal Analysts, must all be men of recognised status. The same course of procedure is adopted with members of other practising professions, the malpractice of which only incidentally endangers human life; the electrical engineer, the naval architect, the practitioner of any other group of applied sciences. Since there is no need for the law of the land to guard such professions against a charge of homicide, the community is left to look after its own interests and protect itself against quackery by the exercise of its own common sense. All the law can do is to specify that no man shall style himself that which he is not, but in the nature of things it is not easy to interfere with the liberty of the subject in calling himself names.

The problem has to be faced, however, and if the public is to be protected against the quack, some process of legislative interference with this liberty will have to be devised. The question is partly a matter for legislative action and partly a matter for organisation along trade union lines.

The established professions are thus fairly well looked after in regard to the training available for youthful aspirants to their service. A regulation academic course is provided, and the matriculated student knows exactly what he has to do—do a humdrum rat-rat through the curriculum, taking the ordinary precautions against getting "ploughed." Provided the career offered is sufficiently respectable, and sufficiently remunerative to outrival the boyish fancy for brick-laying or engine-driving, there will be no dearth of trained men; and if a sufficient number of professional plums are within reach, there will be the necessary incentive to ability and energy. The rising tide of students at the Universities, backed by the free education of the secondary schools, will see to it that anything decent and anything orthodox does not lack recruits.

There is, of course, scope for improvement in all orthodox curricula—vast scope. But the need for improvement and the direction it should take, are usually easy to recognise. Otherwise is it with the more specialised worker who hopes to devote his life to research; more markedly otherwise when his research takes him to the border-lines of his science; and yet more markedly otherwise when his science is the fundamental one of Chemistry

If he is to be a specialist his training in his main subject must be fairly prolonged. The major portion of the time otherwise spent in training for an orthodox professional career must be spent in a more intense concentration on the subject in which he afterwards hopes to do research, and more particularly in the time-consuming task of acquiring "practical technique." Unless his training is to be unduly prolonged his "cognate subjects" must be well chosen, so as to bear upon the prospective border-line, and he must select some unorthodox curriculum for himself. Since this is a sporting procedure, and demands a stronger individuality, or at least a more impelling individual taste, the number of men consciously taking to border-line sciences will remain few, unless some definite career is offered by which consciousness is aroused. As a rule, this incentive is absent, since border-line specialisation precedes its own public recognition, and remunerative occupation therein is "chancey." As soon, of course, as the border-line is roughly mapped out by inquisitive spirits from the pure sciences, the economic possibilities of the new territory become apparent. But the territory remains imperfectly exploited until it is in the position to offer a career to the "honest hodmen of science," whose labour is so necessary to develop it.

The first exploration may demand genius of the highest order; such genius as only appears at intervals in the history of science. But the developing of the new scientific territory demands a host of ordinary, presentable, well-trained brains and capable hands.

The problem of the development of the border-lines of a science, is therefore three-fold.

First and foremost, the purely scientific worker with no utilitarian end in view must be encouraged. Since his end is not utilitarian, but his nutritional needs none the less pressing for that, he must either side-track himself in seeking nutriment in ways alien to his work, in subsidiary uncongenial tasks as the price of his researches: or he must depend upon private or State endowment. The search for truth for its own sake has been hampered through all the ages by the unfortunate circumstance that the most earnest seeker after truth has got a stomach. Private endowment of pure research has done much for progress, especially in America, where it is now fashionable for industrial millionaires to return part of their spoils to strengthen the ladder by which they climbed; as witness Rockefeller. But any nation which relies upon private enterprise for encouraging non-utilitarian work is destined to disaster; is, at any rate, an ass. There must be national endowment of pure research, of the pursuit of knowledge for its own sake, and copious endowment at that. Pure research is the basis upon which the superstructure of economic progress is built.

Secondly, but not less important, there must be provision for the band of workers who commence to carry the data of pure science into fields where it may find its economic application;

who *commence* to apply the science, and carry out research in the zone between abstract truth and downright utility. These are the pioneers of the profession to follow. This phase of the development, also, can not safely be left to look after itself, since in its early stages it must suffer from many failures, and can offer no assurance of a livelihood. It will not attract those "in search of a career," and will therefore suffer neglect. It is a phase of development which is highly specialised, but which has not yet obtained full recognition. It is still "pure science"—pure science doing its best to get itself applied. State endowment is imperative, either direct in the form of grants to Universities for "research fellowships" and "research professorships," or indirect by encouragement of such work in State institutions of a scientific character. This latter method is important, and should not be overlooked, since such institutions are usually well off for apparatus and material for research, and it costs but little to encourage "human quality."

Thirdly comes the every-day application of the results and methods to utilitarian ends. The new science finds its feet, demonstrates its utility to the "layest" of minds, and is no longer so dependent upon endowment. It is self-supporting, obviously adds to the wealth or well-being of the world, and provides careers for whomsoever cares to take it up. The tools are there, the lines of application mapped out, and the journeyman can do the rest. The applied science passes over into a trade. If Britain had spent a trifle in encouraging pure scientific research half a century ago, she would have saved herself the ignominy of having to spoon-feed her industries to-day.

It must never be lost sight of that the purely scientific investigator lays the foundation-stones for the superstructure. Science cannot be applied until there is science to apply, and the genesis of science is always pure in the sense that each link in the chain of development must be forged independently of any purpose to which the whole chain may finally be put. As Huxley put it "What people call Applied Science is nothing but the application of Pure Science to particular classes of problems."

But Applied Science is something anyone can understand, since it touches every-day experience, and there is a danger that applied science will be endowed to the detriment of pure science. The aims of the pure researcher are not so easy to grasp, for the very training in science tends to exalt the idea of knowledge for its own sake, and shed a halo round an hypothesis. It is, perhaps, not easy for the utilitarian to realise the glow of satisfaction which suffuses the mind of the investigator when he feels that his work has opened up a fresh line of thought, or added some cardinal piece of truth to the body of human knowledge, or pricked some current fallacy. The glow is not so very much more intense when the work obviously has an immediate practical application—at any rate, he can glow quite satisfactorily without that! None the less, it is very much to the interest of even the most pure-minded investigator if he keeps an open eye upon any

immediate practical applications. It so happens, however, that the greatest discoveries are made with no eye to their immediate usefulness. When Faraday called his wife into his laboratory to show her the first toy progenitor of the modern electro motor, his enthusiasm was not disturbed by any considerations concerning the practical value of his discovery—he never made a cent out of it, anyway, though the brains which developed his visions were much inferior to his own. The man of affairs is apt to take the production of some valuable new product, by the application of well-worn principles, as a "triumph of science," but it is not for such triumphs that the scientific societies bestow their honours. The worker who is honoured by his colleagues is the one who widens the horizon of truth and knowledge.

It is sincerely to be hoped that the administrators and statesmen who guide our national destinies, now that they have wakened to the need for scientific research, will not fall into the trap of encouraging *only* the "applied sciences" whose immediate utility they can grasp, but will be far-sighted enough *also* to encourage science in the abstract, pure and unalloyed. To them may be commended a study of the history of science. It can never be predicted how soon an abstract laboratory observation will develop enormous economic importance. One of the most striking instances of this is provided by the Hertzian electric waves, which were referred to in the first edition of Karl Pearson's "Grammar of Science," as of no practical application, but which were used for wireless telegraphy by Marconi before the second edition had appeared. But before Hertz came Crookes, and before him Hittorf, Geisler, Maxwell, De la Rue, right back to Faraday, all studying the electric discharge for its own sake; each advancing his science step by step along its logical line of development with no inkling of the future economic significance of his labour. That is the history of science. As Pope said of Leblanc and Faraday: "It is impossible to calculate the capitalised value of the alkali industry founded by Leblanc, who committed suicide owing to poverty, or of the chemical industries based on the work of Michael Faraday, who ended his days in comparative comfort on a Civil List pension."

The administrators who control the money-bags must not ask to see their money's worth before they spend the money. Scientific discovery of any vital kind can not be made to order, although to a certain extent the results of scientific research can easily be applied to order. But science in the abstract must come first and foremost. Scientific Education and Applied Science must run parallel. For the nations which spend most freely in scientific education and research, can be prophesied the greatest economic prosperity.

Section C.—BOTANY, BACTERIOLOGY, AGRICULTURE, AND FORESTRY.

President of the Section:—Ethel M. Doidge, M.A., D.Sc., F.L.S.

MONDAY, JULY 7.

The President delivered the following address:—

THE ROLE OF BACTERIA IN PLANT DISEASES.

The discovery of the causal relation of bacteria to plant diseases is the greatest contribution to phytopathology since the classical work of de Bary on the parasitism of the fungi. If we except the discovery of bacteria in the root nodules of the Leguminosæ, by Woronine (68) as early as 1866, the earliest work on the relation of bacteria to plant diseases was that of Burrill, an American phytopathologist, who, in 1878 (10-11) showed that the disease known as pear blight, which had for many years caused serious losses in the United States, was due to the attacks of a micro-organism which he named *Micrococcus amylovorus*. This was followed in 1879 by Prillieux's papers on a pink discolouration of wheat, due to a Micrococcus (41, 42), and by Wakker's work on the yellow disease of hyacinths, published between the years 1883 and 1889 (64-65).

In spite of the evidence brought forward by these and other workers, great reluctance was still shown by many eminent botanists to admit the truth of their conclusions. Hartig (25) expressed the opinion that, owing to its peculiar structure and the absence of circulatory channels which would serve for the distribution of micro-organisms, the plant is protected from their attacks; and that the cell sap, being acid in reaction, is an unfavourable medium for their growth. In 1882 Hartig gave it as his opinion that there was no such thing as a disease of plants due to bacteria; in 1884 de Bary stated that they had scarcely ever been observed, and in 1885 in his "Lectures on Bacteria," said that the present state of knowledge justified him in regarding "parasitic bacteria as of but little importance as the contagia of plant diseases."

In spite of the opinions expressed by these eminent pathologists, a mass of evidence in favour of the parasitism of plants by bacteria gradually accumulated. Burrill's work on the pear blight was confirmed by Arthur (3, 4) (1884-6), and was fully substantiated ten years later by Waite (62-63), who isolated the organism, *Bacillus amylovorus*, and was successful in reproducing the disease by inoculation with pure cultures. Savastano (46) demonstrated the constant occurrence of bacteria in the olive tubercles, isolated an organism, and obtained typical knots on healthy shoots by inserting minute quantities of the culture into punctures.

About this time Dr. Erwin F. Smith published his earlier work on bacterial diseases of plants: in 1895 (49) he described a bacterial disease of cucumbers, cantaloupes, and squashes, caused by *Bacillus tracheiphilus*, a peritrichiate bacillus which occupies the spiral vessels and tracheids. In 1896, he confirmed the work done by Pammel on the brown rot of cruciferous plants, caused by *Bacterium campestre* (56a); and in the same year (50b) published his investigations into the wilt of potato and tomato plants caused by *Bacterium solanacearum*. Stewart's work on bacterial disease of sweet corn also appeared about this time.

The parasitism of each of the above organisms had been conclusively established, the evidence being based on very careful work along the lines suggested by Koch's premises: the organism had been found constantly associated with the disease, and had been isolated and studied in pure culture; the characteristic symptoms had been reproduced by inoculations with pure cultures, and the organism recovered from plants so inoculated.

Migula, in his "System der Bakterien" (89) accepted the evidence submitted by various phyto-pathologists, and admitted that a number of bacterial diseases of plants had been established, but still considered that the cell walls of plants present great difficulties to the entrance of bacteria, and that stomatal infection is generally impossible.

Fischer (24), however, in the same year, in spite of available evidence, expressed the opinion that, "exclusive of the tubercle bacteria . . . . no single example is yet known of bacteria which can insinuate themselves into the closed cells of a living plant. . . . . From the bacillary gummosis of the grape vine to the scab of the potato, all so-called bacterial diseases of plants are of other origin, the bacteria being only saprophytic contaminations."

Dr. Erwin F. Smith, whose investigations have gone so far to place phytobacteriology on a sound basis, took up the challenge, and (1899) in the controversy which followed, showed the completely erroneous nature of Fischer's statements and "unwarranted assumptions"; since 1901 no one has ventured to question the existence of bacterial diseases of plants, and although the field is comparatively new, and in many parts of the world still untouched, "such diseases have been reported from every continent, and are already known to occur in plants of one hundred and forty genera, distributed through more than fifty families" (52).

Workers in this field are now fairly numerous, although students of plant pathology are usually attracted to the mycological rather than the bacteriological side of the subject, owing to the immense amount of routine work and the vast amount of patience demanded by the latter. However, a number of phytopathologists, particularly in America, have made a special study of bacterial diseases, and there is a considerable amount of recent literature on the subject.

The most outstanding of the recent publications are those of Dr. Erwin F. Smith and his colleagues, on the cause of Crown Gall in plants. After a study of some three years, a white bacterium was isolated from the galls on the Paris daisy, *Chrysanthemum frutescens*, which, by inoculations with pure cultures produced similar galls on this and a number of other plants belonging to several different families (53). This organism is particularly interesting in its action on the plant; it causes a proliferation of the cells, which results in the formation of tumours and in the production of secondary tumours, at some distance from the point of inoculation. The secondary tumours are developed on a tumour strand which bores its way through stems or leaves and reproduces the structure, not of the tissues in which it is found, but of those from which it is derived.

In a number of papers (55-6) Smith has stated his conviction that these plant galls are similar to malignant animal tumours in several particulars. Some of these are:—permanent and very rapid new growth containing all the tissues of the part attacked: enormous round-celled or spindle-celled hyperplasias, great reduction of the amount of conductive tissues, early necrosis, especially of the more fleshy tumours, with renewed growth at the margins, frequent recurrence after extirpation, and extension of the disease to other parts by metastases.

Symbiosis.

It has been sufficiently proved that bacteria do not occur normally in the tissues of sound plants. There are, however, certain well-established cases of symbiosis, in which the plant tolerates, or even derives benefit from, the presence of bacteria in its tissues.

The most familiar example of symbiosis is the relation existing between the *Leguminosæ* and the nitrogen-fixing bacteria which inhabit the nodules on their roots. These bacteria are forms which are present somewhat generally in the soil as saprophytes; they enter the roots of leguminous plants through the root hairs, exhibiting prochemotactic reactions to certain root excretions, and invade the cells of the root, where the rod-like organisms become metamorphosed into considerably larger, branching structures, the so-called bacterioids.

To quote a recent text-book (31): "The view once held that the relation between nodule bacteria and host plants is from the start one of true symbiosis, in which both organisms uniformly derive benefit from the association, has lost ground in the face of recent researches. So far from welcoming the advent of *Bacillus radicicola* to its tissues, the host-plant offers a determined resistance.

"The root hairs constitute the usual portal of entry, and a very definite tissue reaction is produced at the point of invasion. Decided differences in the 'virulence' of the bacteria are

noticed. Some bacteria are not able to effect an entrance at all; others enter and provoke a reaction in the tissues which leads to advantageous nodule formation; and still others injure the host plant. In brief, the bacteria behave toward the plant, at least in the beginning, like true parasites, against which the plant strives to protect itself with all possible means of defence. Eventually a state of equilibrium or armed truce is brought about, in which both bacterium and plant benefit by the association. . .

"Broadly considered, the process of nitrogen fixation by leguminous plants, consists, first, in the penetration of the root tissues by certain bacteria, which establish themselves there in a sort of half-parasitical, half-symbiotic relation; second, in the accumulation of nitrogenous substances by the bacteria under the influence of the abundant carbohydrate food supply available in the plant tissues, the nitrogen used in the constructive process being derived from the atmosphere; and, finally, in the appropriation by the plant of the nitrogenous compounds contained within, or diffusing out from, the nutritionally and structurally modified bacteria (bacterioids)."

It is even claimed that in certain cases the nodule bacteria become actively parasitic. In a recent paper by van der Wolk (61), besides a discussion of symbiotic relationships, the author gives an account of a soy bean disease, which, causing first an etiolated condition, may finally result in the death of the plants. He considers that the trouble is due primarily to the lowering of resistance and decrease of protective products in the single layer of cells lying between the nodule and the rootlet proper. This layer normally acts as an absorbing organ, and also as a barrier to the nodule bacteria. The absence or inefficiency of this barrier results in a condition described as a successful parasitism of the plant by its own nodule bacteria. This trouble appeared to be frequent in *Arachis* and *Glycine* plants growing under unfavourable conditions.

Something of a similar nature to the relation which normally obtains between the nodule bacteria of the *Leguminosæ* and their hosts occurs in the tropical East Indian plant, *Ardisia* (36). Here there is no external evidence of the presence of the bacteria, which are most abundant in the leaf-serratures. In the buds they occur in nodules or pockets at regular intervals 30-50 mm. apart, at a short distance from the edge of the leaf. They multiply and have the effect of making the leaf margins appear somewhat yellowish and slightly swollen, but never cause any serious damage. The bacteria are also present in smaller numbers in the inner parts of the seed, from which they are transferred to the seedling; they are apparently always present in plants of *A. crispa,* but it is not known whether, as in the case of *Leguminosæ,* the plant derives any compensating benefit from the presence of the bacteria in its tissues.

Organisms Pathogenic to Plants.

The micro-organisms causing plant diseases belong for the most part to the family Bacteriaceae as defined by Migula; they are rod-like forms, with or without flagella, and there is no well-established case of a plant disease caused by a coccus form.

Dr. Erwin F. Smith (51), the most eminent of phytobacteriologists, on the grounds of priority, uses the name *Bacterium* for rod-like organisms with polar flagella (Migula's genus *Pseudomonas*) and proposes the name *Aplanobacter* for the non-motile forms.

This terminology is employed in the greater part of the literature on plant diseases, although not in general use by bacteriologists, and is adopted in this paper.

A large group of plant pathogens belonging to the genus *Bacterium* (*i.e.*, rod-shaped organisms with polar flagella, as defined above) form a slimy yellow growth on potato and other media, and are so similar in culture as to be almost indistinguishable. Among these may be mentioned *B. citri*, causing citrus canker; *B. Juglandis*, the cause of the walnut blight; *B. malvacearum*, which is responsible for the angular leaf spot of cotton, *B. campestre*, causing the black rot of cruciferous plants, and many other parasites of greater or less importance. All these, however, causes specific diseases, and cross inoculations from one host to another have invariably failed.

Although, as a rule, a parasite only infects plants of one genus, or of closely allied genera, there are certain organisms which have a much wider range. One of the best known of these is the crown gall organism, *B. tumefaciens*, which is of great economic importance on account of its inroads on fruit trees belonging to the family *Rosaceae*, but which also infects willows, poplars, and other plants belonging to widely separated families (*Compositae* to *Salicaceae*).

Members of nine different families are now known to be attacked by *Bacterium solanacearum* (66) which was originally described as causing a wilt of potatoes and tomatoes. Well defined injury and wilting occurs in plants belonging to the *Leguminosae*, *Tropaeolaceae*, *Euphorbiaceae*, *Balsaminaceae*, *Verbenaceae* and *Pedaliaceae*, when inoculated with this organism; and in several other plants the organism multiplies in the vessels but does not cause serious injury.

Certain soft rot organisms, *e.g.*, *Bacillus carotovorus* also have a wide range of hosts.

Several of the green fluorescent species are pathogenic to plants, including *Bacterium aptatum* (8) causing a disease of sugar beet and nasturtium leaves, and Schüster's potato rot organism, *B. Xanthochlorum* (47).

One of the most destructive parasites belonging to the genus *Bacillus* is the pear blight organism *B. amylovorus*, which is fortunately not known to occur in this country.

Of the species of Actinomyces, a genus of doubtful position

which is usually included in the Schizomycetes, one common soil organism, *A. chromogenus,* causes the disease of potatoes commonly known as scab.

There are also a number of non-motile, rod-like forms such as *Aplanobacter rathayi* causing a disease of orchard grass, and *A. michiganense,* causing a vascular disease of tomatoes.

Many of the bacteria, pathogenic to plants, are extremely resistant to drying, but in spite of this fact very few are known to form endospores. I know of only one plant parasite, *Bacterium seminum* on *Pisum sativum,* which readily produces endospores in cultures (13).

Others, *e.g., Bacillus tracheiphilus,* which causes a wilt of cucurbits, are very sensitive to dessication and to sunlight, but such organisms as these stand a very poor chance in this country, and no one of them is known to cause serious damage in South Africa.

Plant pathogens grow without any difficulty on the ordinary culture media in use in the laboratory, and this is sufficient evidence that they are facultative saprophytes; but little is known of their growth outside of the host plant in nature, beyond the fact that certain parasites can survive for a considerable time in the soil. It is not easy to isolate such organisms directly from the soil, but it is known, for example, that tomato and tobacco seedlings planted in contaminated soil become infected with *Bacterium solanacearum* through wounds in the roots (51), and that *B. tumefaciens* in soil from which plants showing crown gall have been removed, readily infects fresh plants put into the same soil (53).

The soil is the ordinary habitat of *Actinomyces chromogenus,* and it only becomes parasitic under certain conditions.

The optimum temperature for growth usually lies between 20° C. and 30° C., very few grow well at blood heat, so that it is not surprising that inoculations of plant parasites into animals, and *vice versa,* have failed to produce any definite symptoms of disease.

An interesting exception to this rule is found in the cocoanut bud rot common in the West Indies, and found by Dr. Pole Evans to be identical with the disease occurring in Portuguese East Africa. This disease is caused by an organism indistinguishable from *Bacillus coli* (Esch) Migula, and inoculations into cocoanut seedlings with *B. coli* of animal origin, gave infections similar to inoculations with the organisms isolated from the cocoanut (28).

Agents of Transmission.

The transmission of disease over long distances is, in the vast majority of cases, through the agency of parts of plants used for propagation.

There is no doubt that the black rot of cruciferous plants was introduced into this country through seed collected from infected plants. I have repeatedly isolated the organism

Bacterium campestre, from samples of imported seed obtained by local firms (16), and distributed by them through the country; and Smith states (52) that there is good reason to believe that both the black rot of cabbage and Stewart's disease of sweet corn have been disseminated broadcast in the United States by ignorant and unscrupulous seedsmen. Both diseases are transmitted to seedling plants from the seed. The angular leaf spot of cucumber caused by *Bacterium lachrymans* Smith and Bryan (54) has also been shown to overwinter with the seed and cause seedling infection, and epiphytotics of the disease may result from the introduction into the fields of contaminated seed.

In each case quoted above, the organism is carried on the surface of the seed-coat, and the internal tissues of the seed are not actually attacked by the organism; such contamination can easily be removed by disinfection of the seed before planting, but there are other organisms which penetrate the seed coat and attack the embryo. Cotyledonary infection is common in the case of bean plants attacked by *Bacterium phaseoli*, and seed produced locally often shows a high percentage of infection.

A particularly interesting type of cotyledonary infection has recently been described in the case of a bacterial disease of *Pisum sativum* (13). Externally the seed appears sound, and shows no indication of infection, but the organism is frequently present in large numbers in the tissues of the cotyledon, and sometimes in other parts of the embryo; a discoloured area in the centre of each cotyledon is typical of this disease. Infected seeds often fail to germinate, or in less severe cases the shoot is abortive, brown, and dead at the tip, and laterals grow out prematurely to take the place of the main shoot. Sometimes brown streaks are to be seen on the youngest shoots, but otherwise there is no further sign of disease until the flowering period. The organism passes up the stem of the plant in the motile stage, and is to be found in the seed and seed-pod. Very few cases are known of an internal infection of the embryo such as that described above. Bacteria are reported to occur symbiotically inside seeds of *Ardisia crispa* (36). In this plant the bacteria occur in nodules or pockets inside the seed between the embryo and the endosperm. Miehe considers this a case of strict symbiosis. Instances of seed infection similar to that of *B. seminum* are known in the fungi, *e.g.*, in the case of the barley smut (7), (*Ustilago hordei nuda*), mycelium is found both in the endosperm and the embryo of the resting seed, and the fungus during the early stages of the plant growth, grows up with it in a state of semi-symbiosis, without causing any very marked disturbance, until the flower spike begins to develop.

Instances of seed coat infection and infection of ovarial tissues by fungi are not uncommon; in the mycorhiza-bearing plants (43), the mycelium of the symbiotic fungus of the *Ericaceæ* was found to be present in the seed coat, but not in the internal tissues of the seed.

The most striking example of the transmission of disease by means of nursery stock is afforded by the introduction and dissemination of citrus canker, both in this country and in the Southern States of America. Citrus canker was introduced from the East, where it is now known to have occurred in Japan as early as 1863 (33); the South African outbreak has been traced to nursery stock introduced from Japan in 1905 or 1906 (17 b), and nearly every case of canker in a new locality can be traced to the introduction of infected nursery stock (young trees or budwood).

Other cases of dissemination of disease from the nursery can be quoted; apple grafts are known to have transmitted crown gall; the yellow disease of the hyacinth is carried in the bulb (53), and in the case of the black rot of cabbage and cauliflower, the organism is disseminated in seedling plants by nurserymen who supply small town gardens.

The bacterial diseases affecting potatoes are carried in the tuber, and those which occur in South Africa (*Bacterium solanacearum* and *Bacillus atrosepticus*), being of world-wide distribution, have no doubt been introduced into this country with infected "seed" before any adequate inspection was organised.

The soil around infected plants may serve for years as a source of infection. This is particularly the case in orchards and nurseries where citrus canker has occurred. When a tree is destroyed, small pieces of root are almost unavoidably left in the ground, and from these sucker shoots develop, which usually show a large percentage of citrus canker lesions soon after they push through the soil; it is also not uncommon in badly-diseased orchards to find branches touching the ground, or even partially covered with soil, very heavily infected. I have myself succeeded in infecting lemon seedlings from soil taken from an orchard one year after all citrus trees had been destroyed; and recently sucker shoots pushing through the soil eighteen months after the trees had been destroyed have developed the disease.

The crown gall organism (*B. tumefaciens*) survives in the soil for a considerable time. Smith (53) cites the case of a grower of nursery stock who found part of a block of apple trees badly affected with gall. The trees were dug up, and the ground left to rest a year; then peach trees were planted; in that portion where the apple trees had been diseased, most of the peach trees became affected with galls, and were worthless.

Bacterium solanacearum in the soil enters the roots of tomato and tobacco plants through wounds such as might be caused in transplanting, but some organisms (52), *e.g.*, *B. amylovorus* appear to die out quickly in the soil, and no case of pear blight by soil infection is known.

Cases of infection by water used for irrigation are reported by Honing (27) in the case of the tobacco wilt (*B. solanacearum*). In Sumatra the fields are watered from wells, some of which

become infected, probably by the falling into them of infected earth.

An interesting case of infection by flood water has been reported by Mr. Hobson, our chief citrus canker inspector.

The Sterkstroom River flows through a large orchard in the Rustenburg district which was heavily infected with canker. Three miles further down the river there is an orchard containing 500 trees obtained from a nursery where canker has never occurred: five miles down the river there is a second orchard of 100, twenty year old seedlings; all these trees had been carefully inspected three times before January, 1918, and no trace of canker discovered. The summer of 1918 was an exceptionally wet one, and during January the Sterkstroom River was in flood; it submerged the lower three rows in each of these orchards, which are on the river bank. The next inspection in March, 1918, revealed canker infection in 40 per cent. of the three submerged rows in the second orchard, and 60 per cent. in the first. Five seedling lemon trees, apparently self-sown, growing in dense poplar bush between the two orchards on the river bank, were all found infected at the same time.

Citrus canker also affords an interesting example of the so-called hold-over infection, in which case the plant itself harbours the parasite indefinitely. Peltier (39), in experimenting with various citrus hybrids, noticed that certain trees which failed to become infected at the time of inoculation, developed canker on the shoots in the succeeding spring. In the field it has frequently been found that trees from infected nurseries which had been kept under observation as suspects, developed canker only many months after being planted out. An instance recently came to our notice of trees which were derived from an infected nursery four years ago, and which have been repeatedly and carefully inspected without any sign of leaf or bark cankers being found. Recently a number of young cankers showed themselves on one of these trees. In other cases canker has appeared after one, two, or three years.

Wind-blown rain is, without doubt, one of the most important factors in the field and orchard in the dissemination of leaf spot diseases where stomatal infection is the rule; this is the case in the mango blight (*Bacillus mangiferæ*), citrus canker, bacterial shot hole of the apricot (*Bacterium pruni*), and the walnut blight (*B. juglandis*). These organisms all affect the fruit and twigs as well as the leaves.

In making field studies of the mango blight, it was noted (14) that the disease spreads in the orchard during the wet season, and in the direction of the prevailing winds.

Two interesting papers on the agency of wind-blown rain in disease dissemination have recently been published by Faulwetter (22-3), who worked with the angular leaf spot of cotton caused by *Bacterium malvacearum*. He showed by inoculating one row of plants in a cotton field that the disease is disseminated during wet weather in the direction of the prevailing wind.

B. malvacearum was repeatedly isolated from the film of water covering infected leaves after rain or heavy dew; and he was able to show experimentally that water is splashed by a falling drop, only when it falls on a film of water, and that it is the water of the film which forms the splash drops. The distance of the splash varies according to the size of the drop, depth of surface films, elevation and inclination of the surface of impact, and the velocity of the wind. A drop of .02 c.c. in volume, falling 16 feet upon a relatively thin film of water, and a plate 3 feet above the ground, during a wind of 10 miles an hour, splashed water in abundance a distance of 8 feet in moderate quantities as far as 12 feet, and in slight amounts to 16 feet. The possibilities of dissemination of the motile bacteria, which have been shown to emanate from lesions into the surface water film, during a driving rain, are therefore considerable, if one includes the distance bacteria may be carried from the original lesion, then splashed up and carried farther, and so on, until a dilution too great for infection is obtained.

Rain-splash infection is probably responsible for a large proportion of stomatal and water pore infection; but in the case of organisms which enter the host through the nectaries or through wounds, insects are often the agent of transmission.

The first exact experiments in this connection were carried out by Waite in 1891 (62). He isolated the pear blight organism, grew it in pure culture, and established its pathogenicity by inoculations. With these cultures he sprayed blossom clusters in places where the disease did not occur, and obtained blossom blight; the infection travelled back into the supporting branch, and later he found the organism multiplying in the nectar, and re-isolated it. On certain trees he protected some of the flowers from the visits of bees by covering them with mosquito netting, and the protected blossoms remained free from disease; on other trees, where the flowers were not covered, he saw bees visit them, sip from the inoculated blossoms, and then visit blossoms on unsprayd parts of the tree, which soon became blighted. As a final proof he captured bees which had been seen visiting infected blossoms, excised their mouth parts, and from these obtained a culture of *Bacillus amylovorus*, with which he again produced the disease.

Similar experiments, carried out in later years, showed that bees are also responsible for conveying a bacterial disease of pear blossoms in England (5 a) and in South Africa (18): each of the two latter diseases, however, appears to be caused by an organism distinct from *B. amylovorus*, and of a less virulent type.

Recently Stewart (58-60) has shown that various sucking insects, particularly the tarnished plant bug (*Lygus pratensis*) are capable of carrying (*B. amylovorus*) from diseased to healthy shoots, where the bacteria gain entrance to the plant tissues through the feeding punctures made by the insects;

according to Burrill (9), aphides and leaf hoppers are also responsible for transmitting pear blight.

Instances of transmission by insects might be multiplied; curly top of beet (6) is carried by the leaf hopper, *Eutettix tenella;* it has been shown (57) that leaf-eating insects may transmit the wilt disease of solanaceous plants, although possibly in the case of the tomato and tobacco wilt more damage is done by parasitic nematodes, which break the root tissues and prepare the way for invasion by organisms present in the soil; and Smith (51) has succeeded in transmitting the black rot of cabbage by means of the larvae of the cabbage butterfly (*Plusia*). Another well-established case of transmission by insects is that of the wilt of cucurbits (51, 52), where there appears to be an adaption. The striped beetle (*Diabrotica vittata*), which is chiefly responsible for the spread of the disease, shows a marked preference for the wilted parts of the plant, a preference which is apt to prove fatal to melons, squashes, and cucumbers in the vicinity of infected plants.

It has been shown that slugs (*Agriolimax*) carry the cabbage rot (*B. campestre*), and there are indications (52) that molluscs are responsible for spreading the oleander tubercle. There is also circumstantial evidence that birds are capable of transmitting such diseases as the pear blight and the coconut bud rot (28), but this still lacks confirmation.

Factors Favouring Infection.

The bacteria pathogenic to plants are most active in the presence of abundant young and rapidly growing tissue. In one or two instances the place is most liable to attack in the seedling stage, *e.g.*, Stewart's disease of sweet corn caused by *Bacterium Stewarti*, and the wilt of tomato and tobacco due to *B. solanacearum*.

In most of the diseases affecting the parenchyma, the severity of the attack is dependent on the presence of rapidly-growing shoots and fruit, or young leaves. Very numerous cankers can be produced on a young and rapidly growing shoot of a citrus tree by atomising with a culture of *Bacterium citri*, but it is comparatively difficult to infect a mature leaf. The same is true of various other parenchyma diseases such as the mango blight (*Bacillus mangiferae*), the angular leaf spot of cotton (*Bacterium malvaccarium*), and the bean blight (*Bacterium Phaseoli*). In this connection some interesting observations have been made on the infection of walnuts with *Bacterium Juglandis* (57A). The most common and virulent form of infection is at the blossom end near the stigma; bacteriosis very seriously affects small and rapidly-growing nuts, and when once the organism has penetrated the tissues it spreads rapidly until the nut is seriously weakened and falls. In less severe cases the nut does not fall, but the lesions extend through the hull and shell-forming tissues into the kernel, and it becomes deformed

and useless. Should infection occur later, when the outer tissue is beginning to harden and active growth has ceased, the organism does not spread and the points of infection appear as very minute, superficial, dark-coloured areas scattered over the surface of the nut; these late infections, therefore, do very little damage.

Even in the presence of young tissues, however, stomatal infection does not occur unless the atmospheric conditions are suitable; in many cases infection only takes place when there is rain or heavy dew, so that there is a film of water on the leaf. This has an important bearing on epiphytotics of diseases caused by bacteria in South Africa. To refer once more to the walnut blight: in a certain orchard in the Eastern Province the disease is very severe, in seasons when there are abundant misty rains in the spring and early summer, when the nuts are growing rapidly; but when the rains are delayed the damage caused by blight is almost negligible. This probably accounts for the fact that, in the Oudtshoorn district, where the rainfall is slight and takes place in winter, the walnut blight is unknown.

In studying the mango blight (14) it was noticed that the first fruit infections appeared about three weeks after the first steady rain of the season, and citrus canker is almost latent during the early spring, but becomes extremely active after rainy weather in the summer.

Recent studies (45) on the blackleg in the potato show that a high temperature and low precipitation tend to diminish the disease, while a low temperature and high precipitation produce conditions favourable for it. The same may be said for the bacterial spot of citrus occurring in the Western Province. (19) This disease is only known to occur where there is abundant rainfall during the winter, when the fruit is ripening.

Some parasites, in contrast to those previously mentioned, whose activities are limited to young tissues, are able to attack and destroy mature organs. To this class belong the cabbage rot organism, which destroys the pith of cabbage stems and turnip roots, and numerous soft rot organisms such as *Bacillus atrosepticus,* which attacks potato tubers and reduces them to a slimy, evil-smelling mass in the course of a few days. Organisms causing typical vascular diseases also attack mature tissues, occupying the vessels for long distances and not infrequently causing the wilting and death of the whole plant.

How Infection Occurs.

Infection may occur through wounds; in this country serious consequences often follow hailstorms, which bruise the tissues and open the way for the entrance of parasites. The first serious outbreak of the mango blight was after the great hailstorm of 1906, which seriously damaged the trees; and in more than one instance there is evidence that the crown gall organism has entered the plant through wounds caused by hail.

Thorn scratches on citrus leaves or fruit form a ready means of entrance for the canker organism, and many of the lemons grown in the Groot Drakenstein valley become infected with *Bacillus citrimaculans* through thorn scratches.

It has already been mentioned that *Bacterium solanacearum* and *Bacillus tracheiphilus* enter the host through wounds caused by leaf-eating insects, and that the punctures caused by sucking insects afford a means of entrance into pear shoots for *Bacillus amylovorus*.

Until recently it was thought that infection through wounds was the rule, and only a few instances were known where infection took place through the natural openings of the plant. In the light of recent research, however, it seems probable that in diseases affecting the parenchyma, at least, infection usually takes place through the natural openings of the plant, and most frequently through the stomata.

Stomatal infection has been proved in the cases of citrus canker (*Bacterium citri*), the black spot of plum (*B. pruni*), the angular leaf spot of cotton (*B. malvacearum*) and others; and in all probability will be proved in many other diseases where artificial infection of leaves and shoots can be brought about without wounding.

Smith (51) has shown that in the black rot of the cabbage, due to *B. campestre,* the majority of the infections begin in the water pores; these are grouped on the margins of the leaf, and from these points the bacteria make their way into the vascular system of the leaf, and so pass into the stem and other parts of the plant.

Organisms causing blossom blights enter the flower through the nectaries, as in the case of *Bacillus amylovorus* and *Bacterium nectarophilum.* The bacteria multiply in the nectaries and finally destroy the blossoms.

Period of Latency.

Some time elapses between the actual entrance of the bacteria into the plant and the appearance of external symptoms of disease. As in the case of diseases of animals this may be very short or surprisingly long.

Given suitable conditions the soft rot bacteria visibly affect the tissues in 1-3 days.

In the case of leaf spot organisms, the first visible sign of infection is the appearance of dark green areas, which are water-soaked or oily in appearance. This symptom may be visible in 3-5 days (citrus canker), 5-10 days (angular leaf spot of cotton, bean blight), or may take as long as 3 weeks (mango blight).

Some of the vascular diseases develop even more slowly; in the case of Stewart's disease of sweet corn (52) infection usually occurs in the seedling stage, but the maize may be three months old and six feet tall before it finally succumbs.

Such cases, however, are exceptional, and the diseases usually manifests itself in from one to three weeks.

SYMPTOMATOLOGY.

The macroscopic appearance of plants affected with bacterial diseases is not particularly characteristic, and cannot be said to differ materially from that of plants attacked by fungi; except in one or two cases where the symptoms are quite peculiar, it is impossible to state the cause of the disease without a microscopic examination of the tissues.

One of the most common symptoms of disease is the formation of discoloured spots on the leaves; these are at first dark green, and oily or water-soaked in appearance, but subsequently become brown or black. This is the case in almost all the so-called leaf-spot diseases (mango and mulberry blight, angular leaf spot of cotton, etc.), and, in most of these, similar discoloured areas are the result of fruit and twig infections. When the brown spots are numerous, the leaf or fruit frequently yellows and falls prematurely. In other cases, deep red or even purple-coloured spots indicate the presence of a leaf parasite; this is especially characteristic in the bacterial blight of Johnson grass, *Andropogon sorghum*, caused by *Bacillus sorghi*. This red or purple coloration is often noted in the early stages of the shot hole disease of the peach or plum caused by *B. pruni*; in the later stages the leaves show the circular or irregular perforations which give the disease its name.

In other leaf-spots the leaf green persists in the neighbourhood of the spot, while the rest of the leaf becomes yellow (bean leaf spot). The staminate inflorescence of maize attacked by *Bacterium Stewarti* ripens prematurely and becomes white.

Discoloured areas on shoots, as the branch grows older, frequently lead to the formation of extended open wounds or cankers, which are elongated in the direction of the axis of the branch.

The black rot of cruciferous plants is characterised by a blackening of the veins of the leaves, and a subsequent yellowing of the areas of the blade affected; a discoloration of the stem is frequently observed in plants attacked by *Bacterium solanacearum*.

A sudden wilting of a plant which can not be explained by dry conditions of soil or air may often be traced to the action of bacteria, *e.g.*, the cucumber wilt or the wilt of potato, tomato and other plants. When seedlings exhibit this symptom it is not infrequently the result of planting contaminated seed; in such cases the organism attacks the hypocotyl, and the young plant quickly succumbs.

In some diseases, the death of parts of the plant—leaves, twigs or flowers—is the first symptom that is observed. In the fireblight of pears and apples, the young terminal twigs with their leaves and flowers are killed, and even large branches are

involved and succumb. The leaves turn brown and dry up while still hanging upon the tree, and the twig will be found to be dead down to a certain point, which marks the advance of the bacterium which is the cause of the disease.

Necrosis of the terminal twigs is a very conspicuous symptom of the mulberry blight (15), and also occurs in severe cases of citrus canker.

The mulberry blight, which does not seriously affect the common mulberry, is very severe on the black mulberry (*Morus nigra*), or English mulberry, as it is often called in this country; so many of the young shoots are destroyed that the tree is dwarfed, and I have seen trees fifteen years old that were not more than 4-5 feet high. Olive shoots infected with *Bacterium Savastonoi* are always dwarfed, and it has been observed (52) that uninoculated sugar-cane stems soon surpass in height and vigour those inoculated with *Bacterium vascularum*.

On citrus trees infected with canker, the fruit is undersized, and on potato plants which have been attacked early in the season by *B. solanacearum* the tubers remain small.

Dwarfing is also a common symptom in the black rot of cruciferous plants, but less frequently the disease manifests itself in the over development of certain parts of the plant. Cabbage plants affected with black rot in the stem often elongate abnormally, and as such elongation is accompanied by a shedding of the diseased leaves, the plant often comes to have a small terminal tuft of leaves separated from the root by a long stem bearing the scars of many cast-off leaves (51).

A not uncommon symptom in leaf spot disease is distortion, caused by uneven growth subsequent to infection; this is conspicuous in blighted mulberry and walnut leaves.

In other cases the position of the organs is abnormal; the leaves of tomato plants attacked by *Bacterium solanacearum* are bent downwards, and so also are the fronds of the cocoanut palm in which bacterial bud-rot has developed; culms of *Dactylis* attacked by Rathay's disease of orchard grass and buds of sugar cane affected by Cobb's disease, develop knee-shaped curvatures (52).

Adventitious roots develop on the stems of diseased tomato and tobacco plants; and the root system may show an abnormal number of rootlets, giving rise to a tufted mass of fine fibrous roots. This condition is designated " hairy root," and is common in young apple trees attacked by *Bacterium tumefaciens*. The most common effect of the parasitism of this bacterium is the formation of the pathological overgrowths known as galls or tumours; these are frequently located near the surface of the soil in the region of the collar, hence the name crown gall; but the irregular enlargements may appear on the roots or even on the twigs, often developing in great numbers after the tree has suffered severe hail injury.

A diseased condition of the wood is often indicated by the

exudation of gum (5b); this is a conspicuous symptom in the bacterial gummosis of stone fruits caused by *Bacterium cerasi*, an organism which kills the blossom buds and spurs, and then invades the branches, where large cankers are produced. The affected areas, however, can be detected before the bark splits to form the canker by the discoloration of the bark, and the copious exudation of gum from the invaded tissues.

In the early stages of the angular leaf spot of the cucumber, a bacterial exudate collects in drops on the lower surface of the leaf during the night, hence the name *Bacterium lachrymans* (54) applied to the causal organism; and there is frequently a gummy exudate from fruits of the mango affected with the bacterial blight (14).

Storage organs, such as potato tubers, and the fleshy roots and stems of certain vegetables are particularly susceptible to the attacks of soft rot bacteria. In the case of the soft or wet rot of potatoes, the tissues become softened within a few days, and the tuber soon becomes a shapeless, slimy mass with a particularly unpleasant smell. In tropical regions the coconut is seriously affected by a bacterium which causes a rotting of the large terminal bud (28).

Pathological Plant Anatomy.

The bacterial diseases of plants may be roughly divided (51) into three classes, according to their effect on the host.

(1) Diseases of the parenchyma without hyperplasia; these include the so-called leaf spot diseases, which produce discoloured areas on leaf, shoot, and fruit, and often cause dropping of half-formed fruit and premature defoliation; the soft rot must also be included here.

(2) Vascular diseases, where there is a marked occlusion of the vessels; the majority of these cause wilting of the host plant as from drought, owing to the stoppage of the water-ways of the plant by masses of bacteria.

(3) Diseases in which there is more or less distinct hyperplasia, resulting in the formation of cankers, tubercles, and tumors.

In diseases of the parenchyma, infection is, in general, through the stomata; the organism enters the leaf tissues through a stoma, and begins to multiply in the sub-stomatal cavity. The bacteria invade the neighbouring intercellular spaces, and the tension caused by the rapidly multiplying organism causes a splitting and crushing of the cells. The organism is intercellular, and does not penetrate into uninjured cells. Apart from the mechanical tearing and crushing of the cells, due to the multiplication of the bacteria in confined spaces, the solvent action of the products on the middle lamella separates the cells and produces large cavities in the tissues, which become pockets of bacteria. The leaf spot lesions do not extend indefinitely, the multiplication of the bacteria in the intercellular spaces being

apparently arrested by their own decomposition products. The question of the production of antibodies by the plant is one which has received very little attention from phytopathologists, probably owing to the fact that, on account of the small individual value of each plant, the prevention of disease by inoculation would not be practicable, even if it were proved possible; also, in very many of these diseases, given suitable atmospheric conditions and young rapidly-growing tissues, it is possible to produce any number of secondary infections in close proximity to bacterial lesions.

The vascular diseases are characterised by a marked occlusion of the vessels, which may be plugged with bacteria for a considerable length. From the vessels the bacteria invade the parenchyma cells in close proximity to the fibro-vascular bundles, but, as a rule, only after the vessels have been broken down and destroyed. Some of the organisms causing vascular diseases are wound parasites, but others find their way into the tissues through natural openings, *e.g., B. campestre* enters the water pores at the tops of the leaves, and from the parenchymatous tissues which it first invades, makes its way into the vascular system of the plant, and for some time it is confined pretty closely to the spiral and deticulated vessels.

The best known example of the third class of bacterial diseases, *i.e.,* those causing distinct hyperplasia, is the crown gall of plants caused by *Bacterium tumefaciens*. Here the organism is intracellular and does not multiply to any great extent, but it exerts a stimulating influence on the cell nucleus which causes it to divide repeatedly, with the result that large galls or tumours are produced. In these overgrowth there are a number of hypertrophied cells containing several nuclei, usually not more than 2-4 in each cell. From the studies of Dr. Erwin F. Smith, it would appear that most of the nuclear divisions accompanied by cell division are by mitosis, but frequently there have been found nuclei which are lobed and in process of amitotic division, and it is probably in this way that the cells become multinucleate.

Examples of hypertrophy are not only found in galls and tumours, but have also been observed in other types of plant disease.

Citrus leaves attacked by the canker organism show a distinct hypertrophy of the cells of the mesophyll at an early stage of infection, but it is not evident whether this is due directly to the action of the organism, or is a result of the rupture of the epidermis. Küster (32) illustrates hypertrophied mesophyll cells enlarged into vestcular swellings, on the wounded border of a cabbage leaf which strongly resemble those found in an incipient citrus canker, but are considerably larger.

Tyloses are frequently found in the vessels of mulberry twigs attacked by *Bacterium mori*, and have also been observed in potato stems attacked by *B. solanacearum.*

Bacterial Diseases of Plants occurring in South Africa.

The number of plant diseases in South Africa which have been actually proved to be due to the action of bacteria is as yet comparatively small, but does not in any way indicate that bacterial disease of plants are of minor importance in this country; since, in spite of the small number of workers in phytopathology, the number of bacterial diseases known to occur in South Africa somewhat exceeds the number recently recorded (5) as occurring in Great Britain and Ireland. A short summary of the South African diseases may be of interest. It will be noticed that the majority are diseases of wide distribution which have in all probability been introduced into this country with contaminated seed, or nursery stock.

Citrus Canker. *Bacterium Citri* Hasse.

Citrus canker (17) is undoubtedly the most important economically. This was introduced from Japan with nursery stock, and was unfortunately disseminated through the country before the highly infectious character of the disease was realised.

It produces raised, corky areas on the leaves, twigs and fruit of most of the varieties of citrus, being particularly severe on grape fruit, and not only disfigures the fruit but causes it to yellow and fall prematurely. One of the most unpleasant qualities of the canker organism is its ability to lie dormant for months, or even years, in the soil or on to the bark of the tree itself, and to become active as soon as suitable conditions occur. In the nursery it is fatal to the buds, causing a mortality as high as 75 per cent. The occurrence of this disease has led to the closing of Rhodesia against citrus trees and fruit produced in the Union, and the American market is also closed against our citrus fruit until such time as the disease is eradicated. This is not surprising, as the United States have had themselves to contend with a disastrous outbreak in the Gulf States, and have spent large sums of money on the eradication of the disease.

In South Africa citrus canker is confined to the Rustenburg, Pretoria and Waterberg Districts of the Transvaal. One or two outlying cases of infection which occurred, were fortunately in isolated groups of trees, which were immediately destroyed by fire. The infected districts have been placed in quarantine and a vigorous campaign of eradication is in progress within the restricted area; the magnitude of the operations may be guessed from the fact that the canker eradication campaign has cost over £60,000 up to the present, and that 33,737 infected and contact trees, and 416,850 nursery stock have been destroyed.

The disaster to the citrus industry in this and other parts of the world caused by the epiphytotics of citrus canker, illustrates the necessity for a larger number of workers in this field, and for the investigation of problems in phytopathology which

are not of apparent economic importance. The appearance of the citrus canker lesions has been known for many years in the East.

In the herbarium of the Hong-Kong Botanic Gardens there is a collection of *Citrus nobilis* Lour made in 1863 at Nagasaki, Japan, by Maximowicz. This specimen shows a number of citrus canker lesions, and proves the early occurrence of the disease in Japan (33).

In 1904 there appeared in a Japanese publication a description of "a new kind of Pathogenic microbe, being No. 8 of the organisms injurious to citrus"; no name is given to the organism by the author, but his description leaves no doubt that he is referring to the disease now known as canker. The lesions on the host are accurately described, but these had only been noted on nursery stock, and the application of Bordeaux mixture was recommended for the prevention of the disease.

It was in 1905 or 1906 that the nursery stock was imported into this country which introduced the disease, and in 1908 and 1909, when canker became serious at Warmbaths, the study of the disease was dropped when canker was apparently controlled there, owing to the pressure of work on the two plant pathologists then at work in the Transvaal, and owing to the lack of proper equipment, there being no greenhouse facilities for infection work. Had it been possible to complete the investigation at the time, the disease could have been checked at a much earlier stage of its progress, and at a much smaller cost to the country.

Bacterial Spot of Citrus. *Bacillus citrimaculans* Doidge (19).

This disease is of minor importance as compared with the citrus canker. It is limited in its distribution, occurring only in the Groot Drakenstein valley in the Western Province. It causes sunken spots or pits in the fruit, and in some seasons causes considerable loss. The fruit lesions are similar to those of black pit, a disease described as occurring in California (48b), but apparently caused by a different organism. The stem lesions, which occur as brown patches round the base of the thorns, are similar to the Californian "Citrus blast," which is caused by still a third bacterium (39).

Bacterial Blight of Pear Blossoms. *Bacterium nectarophilum* Doidge (18).

Another trouble which appears to be confined to the Western Province is a bacterial blight of pear blossoms, which is troublesome in the Stellenbosch district, and to which some varieties are much more susceptible than others. This closely resembles a blight of fruit blossoms occurring in England (5a), but does not, like the American fire blight, attack the twigs and leaves. Up

to the present the fire blight is not known to occur in this country.

CROWN GALL. *Bacterium tumefaciens* Smith and Towns.

Dr. Pole Evans has shown that the crown gall occurring in South Africa is caused by the same organism (*B. tumefaciens*) as the American gall. Crown gall is a common nursery trouble throughout the country, and sometimes becomes severe in the orchard after hail injury. Willow trees are particularly subject to crown gall, and seem to act as reservoirs of infection for fruit trees in their vicinity.

MULBERRY BLIGHT. *Bacterium mori.* (Boy and Lamb.) Sim (15).

Mulberry blight is of very common occurrence, but does not cause serious injury except to the Black mulberry, *Morus nigra.* It causes spotting and distortion of the leaves, discoloration and necrosis of the shoots, and a general dwarfing of the whole tree.

WALNUT BLIGHT. *Bacterium juglandis.* Pierce (21).

The Californian walnut blight is very prevalent in Natal, both in the nursery and the orchard, and many fine trees have been destroyed, as year after year they failed to produce a crop. It also occurs in the Eastern Province of the Cape, the Orange Free State and the Transvaal, and causes serious trouble when there is abundant rain and cloud in the early summer. The leaves and twigs are attacked, but the most serious consequence is the wholesale destruction of the young nuts, which become badly spotted and fall prematurely.

MANGO BLIGHT. *Bacillus mangiferæ* Doidge (14).

The mango blight seriously affected the export of mangoes from the Barberton district, and the disease is also severe in Natal, and occurs in the Pretoria and Rustenburg districts of the Transvaal. Discoloured blotches appear on the leaves and fruit, and not only are the mangoes disfigured, but when they are attacked early, fall to the ground in great numbers when the fruit is only half grown.

COCONUT BUD ROT. *Bacillus coli.* (Esch) Mig.

Coconut bud rot occurs in Portuguese East Africa, and it has been shown by Dr. Pole Evans that the causal organism is *Bacillus coli,* and the disease is identical with that which occurs in other tropical countries.

ANGULAR LEAF SPOT OF COTTON. *Bacterium malvacearum* Sm.

As the name indicates, the bacterial disease of cotton is characterised by the formation of dark, angular spots on the leaves and bolls. It seems to occur wherever cotton is culti-

vated, and has been reported as troublesome in the Rustenburg District and in Swaziland.

BEAN BLIGHT. *Bacterium phaseoli* Sm. (20).

The bacterial blight of beans occurs quite commonly, and judging by a sample of local seed which was infected to the extent of 75 per cent., must at times be severe. Such seed germinates fairly well, but the hypocotyls of the young plants are attacked, and they soon succumb. It is probable that this disease was introduced into South Africa with infected seed.

BLACK ROT OF CRUCIFEROUS PLANTS. *Bacterium campestre* (Pam.) Sm. (16).

The black rot of cruciferous plants is another disease which has evidently been introduced with contaminated seed; it occurs commonly throughout the country, and in some of the warmer districts makes it impossible to grow cabbages during the summer. The blackening of the veins of the leaves and the fibro-vascular bundles of the stem are the characteristic symptoms.

POTATO SCAB. *Actinomyces chromogenus* Gasp.

The well-known potato scab, causing corky patches and pits on the surface of the potato tubers, is caused by the organism described by Thaxter as *Oospora scabies,* but recently (35) shown to be identical with *Actinomyces chromogenus* Gasp.

BLACK LEG OR SOFT ROT OF POTATOES. *Bacillus atrosepticus* van Hall.

Very little is as yet known of the distribution of the disease known as black leg or stalk rot of potatoes, caused by *Bacillus atrosepticus* van Hall. It occurs in Natal, but whether it can be regarded as a serious trouble there, I have had no opportunity of judging.

BACTERIAL WILT OF POTATO AND TOMATO. *Bacterium solanacearum* Sm

The bacterial wilt of potato, known locally as "vrot-pootje," and the wilt of tomato, caused by the same organism, are very common in Natal and in the Western Province of the Cape; *Bacterium solanacearum* occasionally causes considerable loss in the Transvaal, especially during wet seasons. On the Natal coast it has been found causing a wilt of tobacco, but nothing is known of the occurrence of this parasite on other hosts in this country.

A number of other diseases of bacterial origin are known to occur, but the identity of the causal organism has not been established. These include the shot hole of apricots, crown rot of lucerne, leaf spot diseases of cauliflower, pepper trees, Johnson grass, and other plants.

PROPHYLAXIS.

Very little progress has been made as yet in devising methods of control; the protective sprays which are successfully applied in combating fungous disease have, with one or two exceptions, proved quite useless in the prevention of bacterial diseases, but to quote from Smith's Conspectus (52):—"Although as regards most of these diseases methods of control must still be worked out, with rapidly increasing knowledge of the biological peculiarities of the parasites causing these diseases, and of the ways in which they are disseminated, light begins to dawn, so that before many years have passed we may confidently expect the more intelligent part of the public to be applying sound rules for the control of these diseases—rules based on the individual peculiarities of the parasites and carefully worked out experimentally by the plant pathologist."

It is known that many pathogenic organisms are transmitted on seed, bulbs or tubers; if it is not possible to ascertain whether these are derived from healthy plants, it is possible in most instances to destroy the parasite by soaking the seed or tubers in a dilute solution of mercuric chloride or of formalin. The source of buds, cuttings and grafts should be carefully examined, and these should not be taken from plants showing symptoms of disease. Diseases such as crown gall and citrus canker are frequently disseminated in this way. Another fruitful source of infection is the habit of throwing diseased rubbish on the manure heap; fallen fruit and diseased twigs and leaves can only be safely disposed of by burning.

Soil infection can be avoided by a long rotation of crops, and seed beds used for rearing seedlings of cabbage, tomato, tobacco and other plants subject to bacterial diseases, need to be made with new earth or should be sterilised before planting.

In some cases spraying is effective in checking disease, and germicidal sprays have been used successfully in combating shot hole of the peach and walnut blight; in the latter case Pierce reports that the infection was reduced 50 per cent. Spraying, however, it not always successful; in a number of spraying experiments carried out in connection with the investigation of the mango blight, the fruit on the sprayed trees was as badly diseased as that on the trees kept as controls.

In diseases affecting trees, surgical methods are often useful; the amount of spring infection can be materially reduced by cutting out diseased twigs, and cankers and galls on the larger limbs.

When diseases are known to be transmitted almost entirely by insects, the obvious method of control is to wage a war of extermination against such insects.

Prevention of disease by selection and hybridisation of resistant varieties has not yet received the attention it deserves. Numerous experiments have been made in the direction of breeding rust-resistant wheats, and plants resistant to other fungus diseases,

but little has yet been done in this line in connection with bacterial diseases. Many cases of varietal or individual immunity have been observed, but it frequently happens that varieties which are immune to disease have other less desirable qualities.

The lines along which the problem of disease resistance should be dealt with in the future, are ably summed up by Appel (2) in the concluding paragraph of his paper on disease resistance in plants. He says that "the present methods should by no means be abandoned, for practical experience and happy accidents may help a great deal, but in addition to carrying out these methods, an effort must be made to find the causes of immunity, and after solving this question, to determine without infection the disease-resistant qualities in different varieties and individuals, in order to be able to establish the desired resistance and at the same time to eliminate undesirable qualities. It is only by working along this line that the breeding of disease-resistant varieties on a scientific basis can be accomplished."

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Section D.—ZOOLOGY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.

President—Professor E. Warren, D.Sc.

FRIDAY, JULY 11.

The President delivered the following address:—

TERMITES AND TERMITOPHILES.

I. Introduction.

A comparative study of the modifications of structure and habit occurring in the various foreign organisms living as guests or parasites in the nests of termites and ants offers a very fascinating but difficult field of enquiry. In the case of termites the mutual relationships between the foreign organisms and the members of the termite-community have to be judged chiefly from the nature of the modifications of the termitophiles themselves, and from comparison with myrmecophiles, rather than from actual observation, since termites are less readily maintained under experimental control than ants, being peculiarly intolerant to light and artficial conditions.

Our present knowledge of termitophiles is largely due to the indefatigable researches of E. Wasmann, while F. Silvestri, Ivar Trägardh, H. Brauns and others have made important contributions to the subject.

The termitophiles are mainly insects, belonging to various orders, but in addition there are a few crustacea and other arthropods.

A detailed comparison of the termitophile faunas of the southern continental land-masses is likely to prove of considerable interest in connection with our notions as to the evolution of the termitophiles, and the problem arises as to whether it is capable of yielding some evidence with regard to the occurrence of land-connections between the continents in past geological periods. Unfortunately our knowledge of these faunas is at present very unequal and incomplete. The termitophiles of Africa, South America, and to a limited extent of India and the Malay Region have been studied mainly by E. Wasmann and F. Silvestri, but those of Australia are very inadequately known.

II. Distribution of Termites in Space and Time.

With regard to the present geographical distribution of termites, I have prepared the accompanying table showing the approximate number of species of each genus recorded from the various regions of the world. The table is based on the lists

given by Jules Desneux in his survey of the *Termitidæ* in Wytsman's Genera Insectorum, 1904, and on the faunistic lists of the Zoological Record, London, 1905-1915.

Notwithstanding the fact that the termite-faunas of the different regions have not been equally investigated, yet doubtless the table exhibits the broad features of the present distribution of termites.

Distribution of Termites.

Genera.	N America	Central and South America & W. Indies	South Europe & North Africa.	Æthiopia.	Madagascar.	Seychelles.	Northern India.	Indian Peninsula.	Ceylon.	Japan & Southern China.	Malay Region.	Cocos Island.	Australia & Tasmania.	New Zealand	Samoa & New Hebrides.	No. of Species.
Eutermes ..	1	105	3	111	16	1	1	8	19	3	89	..	19	.	..	376
Termes ..	1	20	3	70	1	..	5	9	9	3	33	..	1	..	..	155
Calotermes ..	2	28	2	20	7	4	1	2	5	5	15	..	10	2	3	106
Hodotermes ..	..	..		14		..	5	3	..	1	..	..	..	..	..	23
Rhinotermes ..	..	4	..	3	..	..	..	..	..	..	16	..	..	..	..	23
Microcerotermes ..	..	..	2	9	2	..	..	1	2	..	3	..	2	..	1	22
Coptotermes ..	..	3	..	3	1	..	1	..	2	5	2	..	3	.	..	20
Mirotermes ..		..	..	16	..	..	..	..	1	..	1	..	1	..	..	19
Microtermes ..	..	3	..	7	..	..	..	5	1	..	1	..	..		..	17
Hamitermes ..	..	..	2	5	..	..	..	2	1	..	3	..	2	..	..	15
Capritermes ..	..	1	..	2	..	..	1	..	2	..	8	..	..	..	..	14
Cubitermes ..	.	..	..	14		..	..	..	..	..	..	..	..	..	..	14
Leucotermes ..	1	3	1		..	..	1	..	1	2	1	1	2		..	13
Eurytermes ..	..	1	1	6	..	..	..	..	2	..	..	.	..	..	..	10
Anoplotermes	..	1	..	7	..	..	..	..	..	..	..	..	..	..	..	8
Syntermes ..	.	7	..	..	.	..	..	..	..	..	..		..	..	..	7
Procubitermes ..		..	.	5	..	..	..	..		..	..	..	..	..	..	5
Arrhinotermes ..	..	2	..	..	..	..	..	1	..	..	..	1	..	..	..	4
Eremotermes ..	..	..	2	..	.	..	1	..	..	..	..	..	..	.	..	3
Porotermes ..	..	1	..	..	..	..		..	..	..	..	..	2	..	..	3
Psammotermes ..	..	..	1	2	.	..	..	..	..	..	..	..	..	..	..	3
Schedorhinotermes	..	..	..	..	..	..	1	..	..	..	1	..	1	..	..	3
Cryptotermes ..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	2
Stolotermes ..	..	..	..	..	..	..	.	..	..	..	..	.	1	1	..	2
Termitogeton ..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	2
Archotermopsis ..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Drepanotermes ..	..	..	..	..	..	..		..	..	..	..	..	1	..	..	1
Mastotermes ..	..	..	..	..	..	..	..	..		..	..	..	1	..	..	1
Prorhinotermes ..		..	..	..		..	..	..	..	..	..	..	..	..	1	1
Psalidotermes ..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Serritermes ..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Termopsis ..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
4 Peculiar S. American Genera ..		7	..	..	..	..	..	..	..	..	..	..	..	.	..	7
16 Peculiar African Genera ..		..	..	24	..	..	..	..	..	..	..	.	..		..	24
7 Peculiar Malay Genera ..	..	..	..	..	..	..	.	..	..	..	11	..	..		..	11
3 Peculiar Australian Genera ..	.	..	..	..		..	..	..	..	..	..	..	6	.	..	6
Total No. of Species	6	188	17	319	27	5	18	31	46	19	185	2	53	3	5	924

The genera, and certain of them may be regarded as sub-genera by some systematists, are placed in descending order according to the number of species contained therein. When the numbers are equal the genera are arranged in alphabetical order.

Inspection of the table will at once show that passing southwards down the great continents the numbers of species of termites greatly increase, thus:

REGION	N. America	Central and South America	South Europe and N. Africa	Southern Africa and Madagascar	N. India	Indian Peninsula and Ceylon	Japan and China	Malay Region	Australia and New Zealand
N	6		17		18		19		55
S		188		346		77		185	

With one or two minor exceptions there are apparently no species common to any two of the regions as above defined. The large genera *Calotermes*, *Termes,* and *Eutermes* possess representative species in all the main regions. It is interesting to note that the most primitive of all the termites, namely, *Mastotermes,* occurs in Australia, just as the most primitive of living mammals. The peculiar genus *Porotermes* has one species in South America and two in Australia.

The first described termite of the oceanic Seychelles Is. was referred to a species (*Eutermes salebrithorax* (Sjöstedt)) of Madagascar, but on the other hand the two species of the Cocos Is. (namely, *Leucotermes insularis* (Wasm.) and *Arrhinotermes oceanicus* (Wasm.)) appear to be distinct from any of the mainland. The three species of New Zealand are *Stolotermes ruficeps* (Brauer), with the nearest ally in Tasmania, *Calotermes insularis* (Walker), which is an Australian species, and *Calotermes browni* (Froggatt) peculiar.

We have but little direct information with regard to the geographical distribution of termites in the past geological ages. From the nature of the present distribution it would appear extremely probable that termites existed in the Secondary Period. However, the earliest known undoubted fossil termites occur in the Oligocene, since it has been shown that the fossil wings discovered in earlier formations, and formerly referred to those of termites, were wrongly so determined.

In the Tertiary Epoch the main termite genera were fully differentiated, and this fact almost conclusively demonstrates that termites arose at a much earlier period. Fossil *Porotermes* *Hodotermes* and *Eutermes* occur in the Oligocene and Miocene

of Florissant, Colorado, while *Termopsis, Hodotermes, Calotermes, Termes,* and *Eutermes* occur in the amber and brown coal of the Oligocene and Miocene of Germany and Austria. It is thus clear that these still-existing genera extended much further north in Tertiary times than at the present day.

We shall consider later as to how far the past and present geographical distribution of termites is likely to assist in defining the ancient configuration of the continental land-masses, and we shall also enquire whether the general *facies* of the termitophile faunas of the present day is such as to throw any additional light on the subject.

III. The Termitophilous Habit.

A termitophile is a foreign organism which lives during the whole or some portion of its life in association with termites. Parasites living inside the bodies of the termites should be excluded from this category.

The relationships between the termitophile and the termites are various, and the structural modifications of the former are likewise diverse. The termitophile may exhibit but little external modification, distinguishing it from closely allied species which do not live associated with termites, or the creature may be so specialized that it is quite unable to live for any length of time when separated from the termites.

From analogy with myrmecophiles it is clear that the termitophile may be regarded with mild dislike, indifference, or with various degrees of esteem by the termite-community.

In no case can we imagine that the termite-community receives any substantial advantage from the presence of termitophiles, since nests which do not contain them seem quite obviously to thrive quite as well or better than those containing them. The benefits of the association are almost entirely on the side of the termitophile which receives domicile, food, and protection from enemies, and accordingly the termitophilous habit must be regarded as a kind of refined parasitism.

An ordinary, permanent, or established parasite has to solve the fundamental problems of: (1) obtaining access to the host, (2) distributing its species, and (3) utilizing the host-species in such a manner as not to exterminate it. The termitophile has the additional problem of inducing the termite-community to permit its presence.

It is clear from the condition of the mandibles that many termitophiles attack the young of the termites and suck the fluids of the body, and thus should the termitophiles in a nest be numerous, the community would be injured by their presence. It is accordingly necessary that the termitophile should adopt some means for cajoling the termite-community, since it is quite obvious that no termitophile could withstand a combined attack by a number of soldiers or workers. The various means adopted may be now summarised:

(1) By the assumption of a simple, rounded contour the body may be rendered inaccessible to easy attack, and further, it may be flattened and very smooth. This is the defensive type ("Trutztypus") of Wasmann. (See Plate 8.)

(2) Less frequently the body is provided with stiff bristles, which would render approach by the termites somewhat troublesome or disagreeable.

(3) It is inherently probable that some termitophiles can protect themselves from attack by the power of producing a scent which is disliked by the termites, and they accordingly avoid the intruders as much as possible.

(4) On the other hand, some termitophiles are not shunned in the least by the termites, and they live in the closest communication with them. These termitophiles may possess no obvious exudatory organs, but they may have well-developed scent glands, and it is to be supposed that the odour is pleasing to the termite-community.

(5) Other termitophiles are provided with conspicuous outgrowths from the body, and their microscopic structure indicates that fluids exude from them. From analogy with myrmecophiles it is certain that these fluids either evaporate and form an agreeable perfume or are licked up by the termites. (See Plate 9.)

(6) In a few cases the bodies of termitophiles carry clusters of bright yellow hairs. Such yellow hairs are frequently present on myrmecophiles, and the ants of the nest have been seen to lick them with great assiduity. Dr. Brauns has drawn my attention to the occasional occurrence of these hairs in termitophiles, and we may suppose that they have a similar attraction to the termites.

(7) Mimicry of inorganic subjects, such as smooth, rounded or oval pebbles, would doubtless assist the defensive type, mentioned under paragraph (1), in avoiding molestation by the termites. Sometimes the bodies of termitophiles are greatly inflated, or physogastric, as it is called, and there may result a marked mimicry of the young or adult termites. This general resemblance to the termites would assist in rendering the termitophiles less liable to attack; but it is doubtful if the origin of physogastrism is to be explained wholly on these lines. (See Plate 10.)

It is very interesting to note that the modification of the termitophiles in all of these different directions is met with in each of the termite regions in which any adequate investigation has been made, namely, the Indo-Malay region, Africa, and South America.

1. *The Defensive Type of Termitophile.*—The defensive type is found in such different termitophiles as a beetle (*Endostomus sudanensis*), a dipteron (*Thaumatoxena wasmanni*), and an isopod crustacean (*Termitoniscus fulleri*).

(See Plate 8.) Thus, here we have a good example of convergence arising through the action of a similar environment.

In the Indo-Malay region, among the Staphylinid beetles, we find a series leading to the maximum type of *Termitodiscus;* the possible steps are indicated by such forms as *Doryloxenus transfuga, Discoxenus lepisma,* and *Hœmitopsenius caudatus.* (Figs. A-D.) In the Æthiopian region the series is less complete, but there is *Pygostemus pubescens* and a number of species of *Termitodiscus.* (Figs. E-F.) In South America the genus *Eupsenius* is closely similar to *Termitodiscus;* and *Termitonannus major* and *Termitopsenius limulus* represent possible stages in the evolution. (Figs. G-I.)

The short, thickened antenna is a characteristic feature of this defensive type, and intermediate stages between it and a filiform antenna clearly occur.

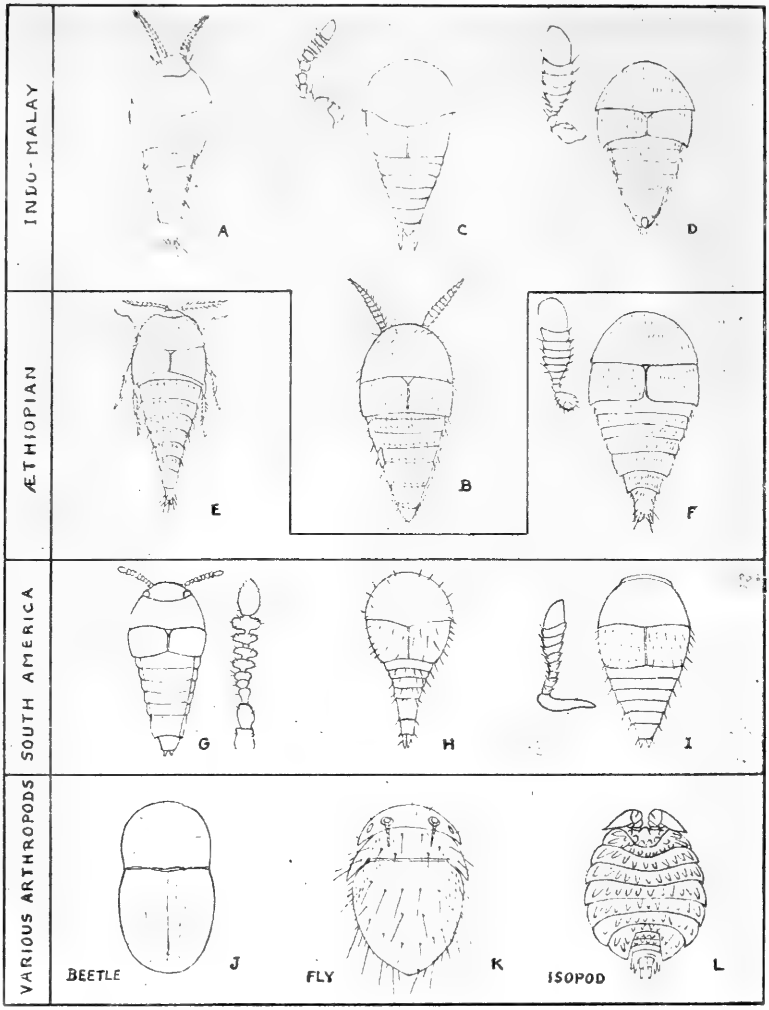
Although such a series can be formed, it does not necessarily prove that evolution proceeded in the manner indicated, but it is significant that similar series can be traced in the three termite regions. With regard to the South American and the Æthiopian regions the question arises whether such a beetle as *Eupsenius* is genetically connected with *Termitodiscus,* or whether the similarities observable are due to convergence. With the undoubted convergence seen in the assumption of the defensive shape in various kinds of unrelated arthropod termitophiles (shown in the bottom row of Pl. 8), and bearing in mind that the apparent gradations observed in South America are not identical with those in the Indo-Malay region, it is probable that the defensive forms have arisen independently in the two continents.

The formation of fine-pointed bristles on the surface of the body is sometimes associated with the defensive shape, and these would doubtless assist in protecting the termitophile. Among adult beetles which do not possess the characteristic defensive shape, a good example of what would appear to be protective spininess is seen in *Termitopulex natalensis* Wasm., a termitophile from the nest of *Termes natalensis;* here the body is densely covered with relatively long, very sharp spines.

It has long been known that insects are very sensitive to certain odours, some being repellent, and other attractive. An interesting paper on the subject has been recently published by N. E. McIndoo.* The power of producing repellent odours at will is a marked-feature among Staphylinids, and where the termitophile is not otherwise modified, and the relationship with the termite-community is not partcularly friendly, the safety of the intruder doubtless depends on its power of producing an offensive odour.

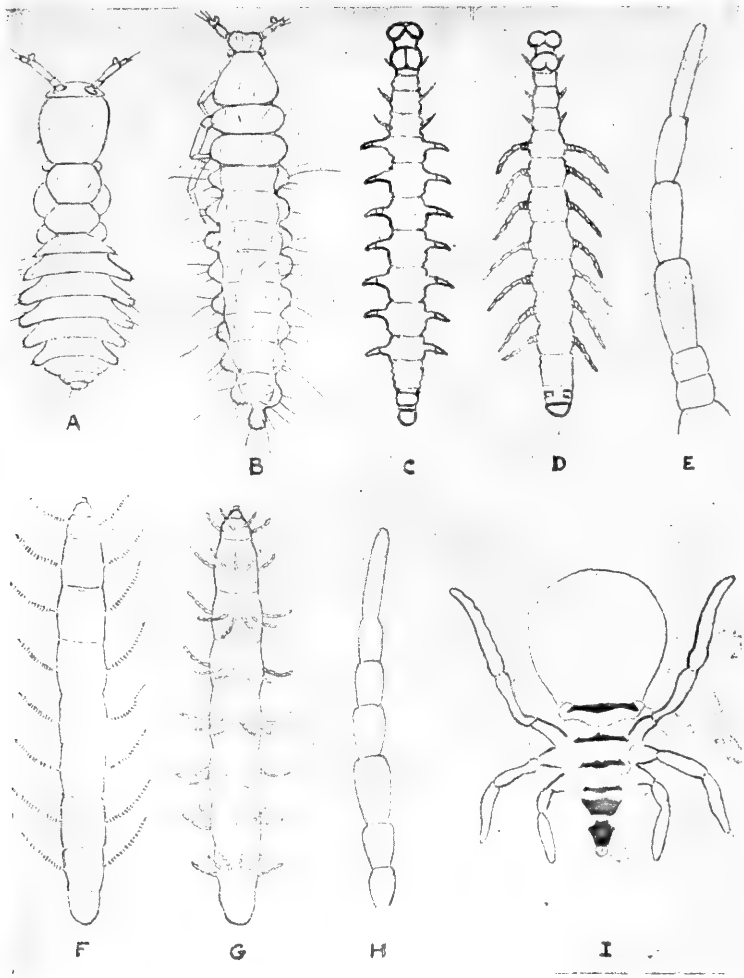
2. *The Seductive and Mimical Type of Termitophile.*—The presence of certain termitophiles is undoubtedly pleas-

* Smithsonian Miscellaneous Collections, **68** [2] (1917).



Defensive Type in Three Zoological Regions.

A, *Doryloxenus transfuga* Wasm. (2.0 mm.). B, *Discoxenus lepisma* Wasm. (2.0 mm.). C, *Hæmitopsenius caudatus* Wasm. (1.3 mm.). D, *Termitodiscus heimi* Wasm. (1.3 mm.). E, *Pygostenus pubescens* Wasm. (2.8 mm.). F, *Termitodiscus splendidus* Wasm. (1 mm.). G, *Termitonannus major* Wasm. (1.8 mm.). H, *Termitopsenius limulus* Silv. (2 mm.). I, *Eupsenius clavicornis* Silv. (1.2 mm.). J, *Endostomus sudanensis* Wasm. (1.8 mm.), K, *Thaumatoxena wasmanni* (B. & B.) (2 mm.). L, *Termitoniscus fulleri* Silv. (4 mm.). [F Original; G, H, I, L after Silvestri; K after Trägardh; A-F, J after Wasmann.]



Exudatory Structures of Termitophiles.

A, Beetle *(Corotoca?)* larva (8 mm.), Natal, with abdominal lateral swellings. B, Beetle (*Termitomimus?*) larva (2 mm.), Natal, with lateral swellings. C, Moth (*Tineid*) larva (15 mm.), Natal, with abdominal unjointed processes. D, *Tineid* larva (14 mm.), Congo, with abdominal jointed processes. E, Jointed process of D. F, Fly (*Muscid*) larva (11 mm.), Madagascar, with lateral, paired, many-jointed processes. G, Fly (*Muscid*) larva (33 mm.), Transvaal, with jointed processes in whorls. H, Jointed process of G *(cf.* E). I, Dorsal surface of abdomen (2 mm.) of beetle, *Spirachtha*, Brazil, with abdominal three-jointed processes. [Figs. D, F, modified after Wasmann, Fig. 1 after Schiödte.]

ing to the termite-community. When little or no external modification of the termitophile can be noticed the friendly relationship is probably associated with the production of an agreeable scent by certain abdominal intersegmental glands.

A. *Exudatory Organs of Termitophiles.*—In the higher type of termitophile, exudatory organs are produced (Plate 9), and there is a remarkable similarity or convergence in these structures in widely different arthropods. That these structures actually exude a fluid, which is licked up by the termites, is rendered extremely probable by Wheeler's* interesting observations on certain ant-larvæ in which thin-walled outgrowths of the anterior portion of the body exude a fluid that is eagerly absorbed by the nurses. One of the simpler types of exudatory structures is seen in certain beetle larvæ (Plate 9, A, B), where the abdominal segments exhibit blunt, thin-walled, lateral swellings, arranged symmetrically in pairs. In the imago beetle we may find, as in *Paracorotoca*† (Plate 10, K), a small median, dorsal swelling between the pronotum and the head, and two larger, lateral swellings as posterior outgrowths from the metathorax.

A similar, segmentally arranged series of outgrowths, but more conspicuously developed, is seen in Trägardh's tineid larva (Pl. 9, Fig. C), and the termitophile at first sight resembles a centipede. In another closely similar tineid larva from the Congo, described by Wasmann, the 7 paired processes are longer and are very definitely jointed (D, E). Again, in a dipterous larva (F) from Madagascar, also described by Wasmann, there are eight pairs of many jointed processes springing from the segments. Recently Mr. Claude Fuller has sent to me an allied larva from the Transvaal, in which the processes are mostly 7-jointed, and are arranged in a whorl on each of eight segments (G). These processes of the dipterous larva closely resemble those of the lepidopterous larva from the Congo (*cf.* H, E). Jointed exudatory organs arising from the abdomen of the termitophilous beetle, *Spirachtha*, were described and figured by Schiödte.

I have carefully examined sections of these exudatory structures of the beetle *Paracorotoca*, of the supposed beetle-larva of the same, of the tineid-larva, and of the dipterous larva, and in no case have I detected definite pores in the cuticle. The cavity of the structures was filled with blood only, or with blood and a certain amount of fat-tissue in addition. In the case of the jointed processes of the fly-larva the cuticle was thick, but very distinctly soft and fibrous in character. There is no doubt that considerable diversity in the nature of chitin occurs, and that some varieites, when pores are absent, are far more permeable to fluids than is generally supposed.

* Proc. of the American Philosophical Society, **57** [4] (1918).
† *Paracorotoca akermani* (Warren)=*Corotoca akermani* Warren.

B. *The Physogastric Condition of Termitophiles.*—In certain of the more highly modified termitophiles there occurs the remarkable condition of the body known as physogastric. The swollen state, which is generally limited to the abdomen, is mostly met with among certain Staphylinid termitophiles, but it must be remembered that it is not confined to them. It is developed in a pronounced degree in the highly specialised termitophilous dipteron *Termitoxenia,* and it is also found in various coleopterous and dipterous larvæ which live in the nests of termites. It is thus clear that the physogastric condition is not due to any special peculiarity in the nature of the Staphylinid beetles, since a similar response to the termite environment arises in such different insects as a beetle and a fly. Physogastrism is not a marked feature among myrmecophiles, although Dr. Brauns informs me that there is some evidence that the little-known larvæ of the myrmecophile *Paussidæ* tend to be more or less physogastric.

A much swollen abdomen occurs in the young and in all the castes of termites, and it has been suggested that the condition is associated with the fact that the food of termites consists so largely of carbohydrates. Since the termitophiles either feed on the fluids of the young or are fed by the workers, it might be imagined that the food received would induce in them a similar physogastric state. Such a purely physiological cause will not, however, wholly explain the phenomenon in the termitophiles, since if this was the chief cause we should expect all closely allied termitophiles to be more or less physogastric, and this is not the case. In addition to any direct physiological effect of the nature of the food, there are apparently a number of other equally or more important causes which combine to favour physogastrism in certain termitophiles, and these are now summarised:

(1) The physogastric condition of the termitophile may have been assisted by natural selection so that the intruder might resemble more closely the termites themselves. We have seen that the condition is normal among termites, and a termitophile, if of the same kind of size as the young or adult termite, would be less distinguishable by the tactile sense, and would be more readily acceptable to the community if the shape of the body mimiced that of the termites. For example, the physogastric Staphylinid *Paracorotoca* is of the same colour as the termites, and with its swollen abdomen it is not easily detected when mixed with a crowd of workers; also, the supposed larva resembles both in colour and in general shape the young termites.

(2) The mimicing effect, however, is less obvious when the abdomen of the termitophile is altogether larger than that of the termites. Such is the case in the large termitophilous larvæ of the Carabid beetles *Orthogonius* and *Glyptus,* but it

may be mentioned that the greatly swollen *Glyptus* larvæ were at first taken to be young queen termites by the discoverer. Nevertheless, it may be surmised that the presence of young queens outside a queen-cell would be likely to arouse enquiry on the part of the termite-community. Similar remarks would apply to the fat dipterous larvæ already mentioned. In these larvæ, the bloated condition of the body is chiefly due to the hypertrophy of the fat-tissue and the formation of much blood. It is to be supposed that the fluids of the blood exude either through special organs or from the general surface of the body and are absorbed by the termites.

(3) In other termitophiles, and especially in the beetles and in the imago *Termitoxenia,* the swelling of the abdomen is due to the hypertrophy of the fat-issue, generative organs and mesenteron. The ovaries and oviduct may be of exceptional size, owing to the fact that the eggs tend to be very large, and are provided with much yolk, or viviparous young may be produced. The reason for this is probably to be sought in the advantage which the young would possess in starting their life in the community in a well-developed condition. The hypertrophy of the fat-tissue is doubtless associated with the exudation of stimulating fluids much liked by the termites, and thus stifling any hostility which might otherwise be displayed towards the termitophiles.

In the case of *Paracorotoca* the male is not much smaller than the female, and the testes are greatly hypertrophied. The amount of semen that can be produced must be excessively greater than is necessary, for the spermatheca of the female is quite small. It is difficult to see how the species can obtain any advantage from the huge size of the testes, for the amount of spermatozoa that could be produced would be sufficient to fertilize an indefinite number of females. The advantage of an enlarged ovary can be recognized, and it would appear that the stimulus (or hormone) for the excessive growth of the gonad in the female is incidentally transmitted to the male.

(4) In some termitophiles the physogastrism is due almost entirely to the enormous development of the sexual glands. For example, in *Jacobsonella* (Plate 10, B), the imago in a non-breeding condition is only slightly physogastric, but Silvestri figures a gravid female in which the abdomen is globular and very greatly distended.

(5) With reference to the food of the termitophiles it would seem certain, judging from the development of the mandibles, that the majority, at any rate occasionally, suck the juices of young termites. From analogy with the myrmecophiles it is quite probable that, in addition, they are fed with saliva by the termite workers. In this case the relatively innutritious diet would account for the large size of the mesenteron. In the gut of *Paracorotoca* and *Termitomimus* I have found no solid matter whatever, and the œsophagus is only adapted for suck-

ing fluids. In these two beetles salivary glands of the usual type could not be traced, and consequently there can be little or no reciprocity in the matter of saliva feeding.

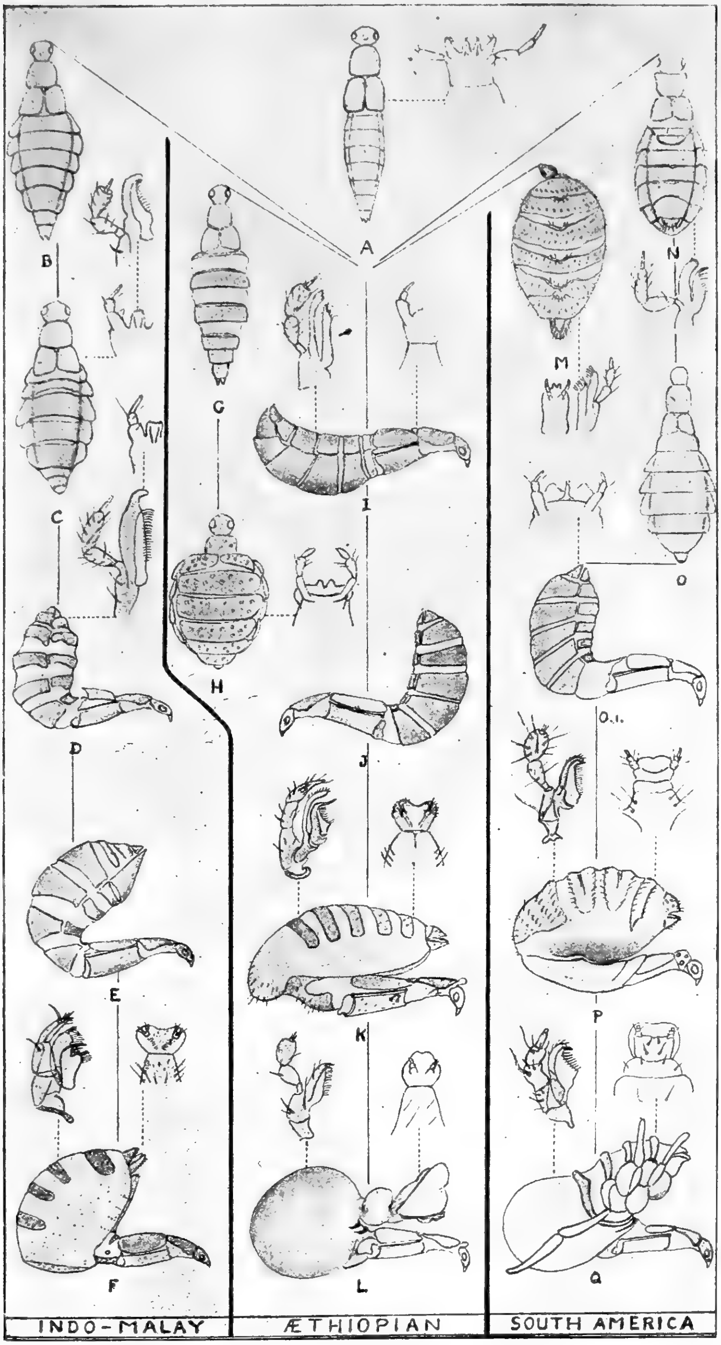
We now see that the physogastric condition of termitophiles arises in a number of ways, and the causes which produce it are accordingly diverse and complicated.

3. *The Physogastric Staphylinids of Different Zoological Regions.*—In three termite regions, which have been especially studied, namely, South America, Indo-Malay Region, and Africa, we find a very interesting parallalism in the development of this peculiar physogastric condition among the Staphylinid termitophiles (Plate 10).

In the Indo-Malay Region, starting from a comparatively unmodified beetle, such as a species of *Myrmedonia* (A), we pass by a series of species to a maximum type, *Termitoptochus* (F), recently described by Silvestri. The upturning and forward extension of the abdomen increase as the physogastrism becomes greater. In the Æthiopian region there are two types: (1) Where the inflated abdomen is not upturned, and (2) where the upturning does occur; the maximum stages being respectively *Termitobia* (H) and *Termitomimus* (L). In South America we also have the same two types reaching extremes in *Timeparthemus* (M) and *Spirachtha* (Q) respectively. Two roughly parallel stages in the three regions are represented by *Termitotima* and *Termitoptochus* in the Indo-Malay Region, *Paracorotoca* and *Termitomimus* in Africa, and *Corotoca* and *Spirachtha* in South America.

As we pass down to the extreme types of physogastrism there may be noticed a gradual reduction in the labium; the paraglossa and lingua become greatly reduced or lost, and the labial palps shorten excessively and lose most of the joints. This modification of the labium accompanying physogastrism is regarded by Wasmann as being due to the loss of function resulting from the termitophile being fed by the termites. It must be remembered, however, that the great development of the mandibles unmistakably points to a partial continuance of a carnivorous habit.

4. *The Dispersal of Termitophiles.*—The method of the dispersal of the species in certain termitophiles is exceedingly obscure. This is more especially the case when the termitophile is highly specialized and passes all stages of its life within the termite nest. The imagos of the moth and dipterous termitophilous larvæ mentioned above are doubtless free-living, and eggs could be laid at the entrance to the nest; but in the case of viviparous, physogastric staphylinids and the physogastric dipterous *Termitoxenia*, which cannot withstand desiccation, or live for any length of time outside the nest, the means for dispersal are not clear. In Natal, the imago of *Paracorotoca* is exceedingly scarce, and there may be only a single specimen in a



PHYSOGASTRIC BEETLES FROM THREE ZOOLOGICAL REGIONS.

A, *Myrmedonia* (unmodified condition). B, *Jacobsonella termitobia* Silv. C, *Disticta capritermitis* Wasm. D, *Asticta butteli* Wasm. E, *Termitotima assmuthi* Wasm. F, *Termitoptochus indicus* Silv. G, *Termitopædia Kohli* Wasmann. H, *Termitobia physogastra* Wasm. I, *Termitotecna braunsi* Wasm. J, *Idiogaster escherichi* Wasm. K, *Paracorotoca akermani* War. L, *Termitomimus entendveniensis* Träg. M, *Timeparthemus regius* Silv. N, *Termitophya heyeri* Wasm. O, and O1, *Xenogaster inflata* Wasm. P *Corotoca melantho* Schiödte. Q. *Spirachtha eurymedusa* Sch. [Figs. F, M after Silvestri, K original, L simplified after Tragärdh, P and Q after Schiödte, remainder simplified after Wasmann.]

nest. Under such circumstances sexual impulse may lead the beetle to wander out of the nest on damp evenings, and it might then enter a neighbouring nest. Such a mode of dispersal would, of course, be very slow, and would only apply to those termitophiles living with termites, which build their nests in close proximity to one another. On one occasion I observed a minute termitophile beetle-larva clinging to the body of a termite worker. Even if such a larva attached itself to the body of a winged imago issuing from a nest there would seem to be little chance of it surviving the long and tedious operations of starting a new colony by a single pair of sexual termites.

There is no great tendency for an external reduction in the eyes of even the highly specialised termitophiles which live in the dark nests of the termites; but I have recently ascertained that the histological structure may exhibit great degeneration.

5. *The Gait and Power of Movement of Termitophiles.*—Insufficient observations are available as to how far termitophiles may mimic termites in their general movements. The flat, defensive type like *Termitodiscus* has a singular gliding gait, which is quite unlike that of termites, but it is peculiarly unobtrusive, and is very suitable for termitophiles which are merely tolerated by the termites.

Some of the Staphylinids are exceedingly agile, and they dart about the nest with slippery activity. This was particularly noticed in the case of *Termitopulex natalensis* Wasm., a slim, black species, covered with long bristles, and living in the nest of *Termes natalensis* (Hav.).

On the other hand, the general gait of the termitophile may resemble that of the termites. The physogastric staphylinid *Paracorotoca* is quite as active as a termite worker, and it is generally found towards the periphery of the nest in company with a crowd of workers. Correspondingly the supposed larva of *Paracorotoca* is always found in company with the young of the termites, and its movements are similarly slow.

When termites are alarmed by opening the nest, or by sudden exposure to light, they agitate or vibrate their bodies in a characteristic manner. Dr. Conrad Akerman, who first discovered *Paracorotoca*, made the very interesting observation that the termitophile also vibrates its body, and when suddenly exposed to strong light, both termitophile and surrounding termites vibrate in a perfectly similar manner. It is difficult to see that there can be any utility in this habit on the part of the termitophile, and although it is a case of marked similarity in habit, we can scarcely imagine that it arose through the natural selection of small variations. It may be even doubted whether there is any utility in the habit on the part of the termites themselves, although shaking the body might possibly frighten ants or other small enemies, and the soldiers tap their mandibles against the ground with considerable force when alarmed. Possibly it is merely a reflex nervous action analogous

to trembling through fright in mammals, and, if so, we could assume that the same environment has produced the same nerve-tone in both termites and termitophiles.

6. *The Relationship Between the Number and Character of the Termitophiles and the Social Life of the Termite with which they occur.*—The mode of life and general characteristics of different species and genera of termites, of course, differ, and it would be of great interest to trace the resulting effect on the various termitophiles.

Among parasites in general we seldom find the same identical species of parasite in different host-species; it does occur, but it must be regarded as exceptional. Similarly, except in the case of some dubious termitophiles, the same species of termitophile is not very often found associated with more than one species of termite.

Thus, although *Termes vulgaris* Havil. and *Termes latericius* Havil. are closely similar to each other in external morphology, and they are both fungus-growers, and their nests occur in close proximity, yet the *Termitoxenia,* which may be found in both of them, belong to different species.

On the other hand, allied termitophiles exhibit some tendency to occur in the nests of similar termites, but the relationship is not at all clearly defined.

Thus, the dipterous larvæ with jointed processes, from the Transvaal and Madagascar, both occur in the nests of *Microcerotermes.* The two known species of termitophilous tineid larvæ both occur with *Rhinotermes.* The peculiar and highly modified flies of the family *Phoridæ* all occur, as far as I am aware, in the nests of *Termes.* Nevertheless, marked exceptions may be noticed; for example, we find highly modified physogastric staphylinids in the nests of fungus-growers and in those of non-fungus-growers; also the two quite similarly modified isopods, *Phylloniscus* and *Termitoniscus,* are found, respectively, in the galleries of *Hodotermes* in the Free State and in the nest of *Termes bellicosus* in West Africa.

It should be noted in this connection that termitophiles tend to exhibit such striking differences in their morphology that systematists have founded a great number of mono-typical genera. The same phenomenon, but in a less striking form, is seen, for example, in bird-lice. Every species of bird tends to have its own species of louse, but in this case the morphological differences are not so great as to lead to the creation of a new genus for nearly every species.

The great majority of the described termitophiles occur in the nests of the species belonging to the large and specialised genera *Termes* and *Eutermes.* Very few have been described from the nests of the more primitive genera *Calotermes, Leucotermes,* and *Coptotermes.* For example, in South America the species of *Termes* and *Eutermes* comprise less than 70 per cent.

of the total number of termite species; but they possess nearly 90 per cent. of the total number of described termitophiles. Perhaps fungus-growers tend to have rather more termitophiles than non-fungus-growers, but the evidence is far from conclusive, and it is clear that very few, if any, of the termitophiles actually feed on the fungus.

The more primitive termites, such as *Calotermes*, make their nests in the decayed branches of trees; they have a less complicated social economy, and are less capable of providing such accommodation as is necessary for the majority of termitophiles.

As examples of the number and variety of termitophiles which may occur with a species of termite, the following figures have been drawn from Wasmann's lists:—

In the nests of *Hodotermes viator* and *H. mossambicus* from Africa: Coleoptera 6, Hymenoptera 1, Isopoda 1=total of 8.

Termes natalensis Hav. from Africa: Coleoptera 9, Hymenoptera 3, Pseudoneuroptera 1, Diptera 1, Thysanura 1=total of 15.

Termes obesus Ramb. from India: Coleoptera 29, Diptera 3, Thysanura 2=Total of 34.

Now, *Hodotermes* is a more primitive genus than *Termes*, and has a less stable domicile, and, according to present evidence, the termitophile fauna of the former is less rich than that of the latter.

IV. Comparison of the Termitophile Faunas of the Various Regions.

Genuine termitophiles appear to be confined to the arthropods and mainly to insects, although an earthworm (*Notoscolax termitocola* Mich.) and a few other odd creatures have been described as termitophile in character. It will be interesting to obtain some notion of the relative frequency with which the different orders and families of arthropods are represented among the known termitophiles, and also as to how far these proportions are maintained in the various termite regions of the world. The actual figures given in the accompanying table are only roughly approximate, since it has not been possible to obtain access to all the literature, and recourse has been had to the Zoological Record for some of the entries.*

Notwithstanding this fact, and although the different termite regions have not been equally investigated with regard to the termitophiles, yet it is believed that the table does represent in broad outline the general trend of the termitophile faunas.

* I have much pleasure in acknowledging my indebtedness to Dr. H. Brauns, of Willowmore, C.P., for his ever-ready kindness in lending literature and in providing valuable information from his rich store of knowledge relative to African entomology.

Distribution of Termitophiles.

Families, etc.	N. America.	S. America	Europe.	Æthiopia.	Madagascar.	India.	Ceylon.	Japan and China.	Malay Region.	Australia.	No. of Species.
Cicindelidæ	..	5	..	1	..	..	1	..	..	..	7
Carabidæ	..	1	..	10	..	1	3	..	1	..	16
Staphylinidæ	3	47	..	45	3	21	30	2	9	7	167
Pselaphidæ	..	6	..	3	..	..	..	..	4	4	17
Scydmænidæ	..	2	..	..	..	..	..	..	..	..	2
Silphidæ	..	1	..	..	..	..		..	..	..	1
Histeridæ	..	7	1	12	..	1	2	..	..	1	24
Lathridiidæ	..	..	..	1	..	..	..	..	..	..	1
Scarabæidæ	..	8	..	22	..	6	5	..	..	2	43
Lymoxylonidæ	..	2	..	..	..	..	..	..	..	..	2
Tenebrionidæ ..	..	..	..	5	..	1	1	..	..	1	8
Cossyphidæ	..	..	..	2	..	..	..	..	..	..	2
Rhysopaussidæ	..	..	..	41	..	3	..	1	7	..	52
Curculionidæ	..	1	..	..		..	..	..	..	..	1
Brenthidæ	..	..	..	..	..	..	..	..	..	1	1
Chrysomelidæ	..	..	..	..	..	1	1	..	..	..	2
Erotylidæ	..	..	..	1	..	..	..	..	..	1	2
Isoptera	..	2	..	3	..	..	3	..	..	..	8
Formicidæ	..	7	..	8	2	..	8	..	..	..	25
Apidæ	..	6	..	..	..	..	..	..	..	..	6
Heterocera	..	..	..	2	..	..	1	..	..	..	3
Diptera	..	5	..	6	2	3	3	..	3	..	22
Hemiptera	..	1	..	..	..	1	..	..	..	..	2
Homoptera	..	..	..	..	1	..	..	..	..	..	1
Coccidæ	..	2	..	1	..	..	..	..	..	..	3
Termitocoridæ (Aphidæ)	..	2	..	1	..	..	..	..	..	1	4
Pseudoneuroptera (Embidina)	..	..	..	1	..	..	..	..	..	..	1
Orthoptera	..	2	..	2	..	..	1	..	..	..	5
Thysanura	..	3?	..	22	..	7	5	..	1	..	38
Arachnida (other than Acari)	1	1	..	2	..	..	..	..	1	..	5
Acari	..	5	..	5	..	..	1	..	..	..	11
Isopoda	..	..	..	5	..	..	..	..	..	..	5
Myriapoda		3	..	4	..	..	2	..	..	..	9
Totals of Species ..	4	119	1	205	8	45	67	3	26	18	496

Reference to the table at once shows that the *Coleoptera* include by far the greatest number of termitophiles. Out of a total of 496 species no less than 348, or 70 per cent., are beetles.

In South America, out of 119 species of termitophiles, there are 80 beetles, in the Æthiopian region (including Madagascar) out of 213 species there are 146 beetles, and in India and Ceylon, out of 112 species, 77 beetles. The percentage number of beetles relative to the total number of termitophiles in the three regions

remains remarkably constant, being 67 per cent., 69 per cent., and 68 per cent., respectively.

The *Coleoptera* have been divided into some 85 families, and out of these only 17 are represented among the termitophiles. Of these 17 only 8 possess more than two termitophiles, and by far the most important are the following 4 families: The *Staphylinidæ* with 167 species, the *Rhysopaussidæ* (related to the *Tenebrionidæ*) with 52, the *Scarabæidæ* with 43, and the *Histeridæ* with 24. Thus the Staphylinids are pre-eminent in the power of adapting themselves to the life of a termitophile. It may be remarked that systematically there is no particular relationship between the four families above mentioned; but the *Staphylinidæ, Scarabæidæ,* and *Histeridæ,* are all included in the *Pentamera* group, which is generally regarded as the highest or most specialised; nevertheless, it extends backwards into far-distant geological periods.

In Staphylinids, glands which are undoubtedly scent organs tend to be especially well-developed, and perhaps this is the main reason why this family should have found it comparatively easy to adopt the termitophile life. In *Paracorotoca akermani* there are some exceptionally large inter-segmental abdominal glands with rounded chitin-lined receptacles opening to the exterior, and it is very probable that these are scent glands. There is no doubt that termites are very sensitive to scents, and it appears that the majority of the odours produced by Staphylinids happen to be agreeable to them, although in certain cases it would seem that the odour is disliked, and it would then serve as a protection against attack.

The numbers of species of Staphylinid termitophiles occurring in three of the termite regions are remarkably close to one another. Thus we have 47 in South America, 48 in Africa and Madagascar, and 51 in India and Ceylon. This is probably to be accounted for by supposing that the termite faunas of the three regions are of such a nature as to have presented in each region a similar range of opportunities for the evolution of these termitophiles.

On account of the great uniformity in the environment of a termite-community, in whatever country it may be situated, it might be very reasonably supposed that any termitophiles occurring at the time of the dispersal of the termites into the various regions would persist in a little altered condition to the present day, and a great similarity in the genera of the different termitophile faunas might be expected. We find, however, that, notwithstanding the general likeness in the size and character of the various faunas, the genera in the Æthiopian region are mostly quite distinct from those of America, but they have a definite affinity with those of the Indo-Malay Region. In this connection it should be noted that the *Rhysopaussidæ*, of which there are some 41 species in Africa, appear to be unrepresented

in South America; also the numbers of termitophilous Scarabæids in Africa and South America seem to differ widely.

From these facts we judge that the termitophilous beetles do not constitute a special fauna common to all the termite regions, and descended from an ancient termitophilous fauna distributed with the termites in past geological periods. The very marked superficial similarity in the more highly specialised termitophilous beetles, such as *Corotoca* of South America and *Paracorotoca* of Africa must be regarded as due to convergent evolution starting from a different origin in the two regions.

On the other hand the occurrence of the genera *Termitodiscus*, *Corythoderus*, and certain *Myrmedonia* species in both Africa and the Indo-Malay Region indicates a somewhat close connection between these two termitophile faunas.

If we now turn to the other termitophilous arthropods in the table, we find that, with the exception of the minute *Thysanura*, which have been insufficiently investigated, the numbers of recorded species are quite small. It is interesting to note that the various groups listed tend to be represented in all the regions, thus indicating that these groups possess a certain definite adaptibility not present in other arthropod groups.

There is an obvious similarity in the numbers of such recorded termitophilous species in the different termite regions; thus in the South American and African regions we find the respective numbers in the *Isoptera* to be 2, 3; in the *Formicidæ*, 7, 8; in the *Diptera*, 5, 6; in the *Acari*, 5, 5; and in *Myriapoda*, 3, 4.

The main exceptions which appear are the termitophilous *Apidæ*, described only from South America, and the *Isopoda* from Africa.

Among the more interesting and specialised termitophiles occurring in these different groups of arthropods are the termitophilous *Aphidæ* (*Termitocoridæ*) and the *Diptera*.

The physogastric dipteron *Termitoxenia* (*Phoridæ*) has short, peculiar thoracic appendages which, according to Wasmann, are the wings modified into exudatory organs. Wasmann further states that *Termitoxenia* is hermaphrodite, and the larval stage is lost in the ontogeny. This genus or allied genera are found in Africa, India, Ceylon, and the Malay Region. The *Phoridæ* belong to the *Brachycera*, and *Termitoxenia* possesses short modified antennæ. In South America the nearest representative to *Termitoxenia* from a termitophilous aspect is the physogastric genus *Termitomastus* (*Termitomastidæ*) belonging to the *Nemocera*; here the antennæ are long, filiform structures, and the wings are less modified than in *Termitoxenia*.

Thus, again, in these diverse arthropod groups we notice that the termitophile faunas in the different termite-regions do not exhibit a fundamental unity which would warrant a belief in the existence of a special termitophile fauna descended from

one existing at the time of the dispersal of the termites. Nevertheless, as in the case of the beetles, the Æthiopian and Indo-Malay regions are connected by the occurrence in both of the highly specialised dipteron *Termitoxenia*.

Speaking generally, it may be said that the termitophile faunas of the different regions are being gradually evolved from the surrounding faunas, and there are no obvious relics of an ancient fauna of termitophiles. The very striking similarities in the external aspect and in the numbers of species in the different regions are to be accounted for by the fact that the termite communities provide similar opportunities and a similar uniform environment in all parts of the world.

V. Comparison of the Termite Faunas of the Various Regions.

In examining the table given on p. 94 we at once notice that the Æthiopian region contains by far the largest number of species. The genera and subgenera of termites are not as yet satisfactorily defined, but, according to the table given, there are in this region 319 species and 33 genera, 18 being peculiar. In the Indo-Malay region there are 280 species and 25 genera, 9 being peculiar; in South America and Central America there are 187 species and 18 genera, 6 being peculiar; and in Australia and Tasmania there are 56 species and 17 genera, 7 being peculiar.

In the first three regions mentioned we find an average of about 10 species to a genus, while in Australia there is an average of only about 3 species. Thus Australia would seem to be poor in species, but relatively rich in genera. The general *facies* of the Australian termite fauna is ancient and primitive: the remarkably primitive genus *Mastotermes* occurs in this region, and the number of species of the unspecialised genus *Calotermes* is relatively high. If we calculate the ratio of the number of *Calotermes* species to the total number of the termite species in the various regions, we find that in Africa 6 per cent. of the fauna are *Calotermes,* in Indo-Malay Region 8 per cent., in South America 15 per cent., and in Australia 19 per cent.

A marked preponderance of *Calotermes* species may also be noted in the northern boundaries of the termite regions; thus in North America the ratio is 33 per cent., and in Japan and Southern China, etc., 26 per cent. Madagascar, being an island, may be left out of this comparison, since *Calotermes* would be more readily distributed by drift wood than any other termite.

Next to *Mastotermes*, the most primitive termite genera are *Termopsis* and *Archotermopsis;* the former occurs in North America, and the latter in Kashmir, North India.

The less specialised and more primitive termites may be regarded as being comprised in the genera *Mastotermes, Termopsis, Archotermopsis, Calotermes, Leucotermes,* and *Coptotermes*. If the species contained in these genera in any particular

region are added together, and compared with the total number of species of that region, then the percentage will indicate the general *facies* of the termite fauna. The following table has been prepared in this manner:—

Region	Percentage of Primitive Species	Region	Percentage of Primitive Species	Region	Percentage of Primitive Species	Region	Percentage of Primitive Species
N. America	67	S. Europe & N. Africa	18	N. India	22	Japan & China	63
S. & Central America	18	Æthiopia	9	Indian Peninsula and Ceylon	13	Malay	9
		Æthiopia (excluding Madagascar)	7			Australia and Tasmania	30

We are led to the following conclusions:—

(1) There is an ancient or primitive aspect to the northern and southern portions of the termite area, taken as a whole. Thus North America, North India, Japan, and China along the northern boundary, and Australia in the south possess such a fauna.

(2) Africa possesses the highest termite fauna, since it contains a greater number of species, and has a larger percentage of species belonging to the more specialised genera than any other region in the world. For the comparison drawn it may be objected that the comparative areas of the different regions should be taken into account. If such is done the broad results would not be essentially changed, since it may be noticed that in the relatively small area of the Malay Region some 185 species have been recorded, while from the Indian Peninsula and Ceylon only 77 and from the whole of Australia only 53.

(3) Next in order comes the fauna of the Indo-Malay region, which includes the Indian Peninsula, Assam, Malay Peninsula, and the Malay Archipelago. These regions possess a greater proportion of species of less specialised genera than is found in Africa.

(4) South America, including Central America and West Indies, possesses a fauna which is somewhat more primitive than that of the Indo-Malay region, and the number of species recorded is considerably smaller, being 188 to 262.

(5) The Termites of North America are few in number and primitive in character.

(6) The termites of Japan and Southern China are few, but there is a high percentage of unspecialised species.

(7) In Australia the number of species in the termite fauna is somewhat low, but there is a high percentage of unspecialized and archaic forms.

The above facts suggest the following hypothesis:—

Since in the Tertiary Epoch the genera *Termes* and *Eutermes* were fully established, we must suppose that in Pretertiary times, when the contour of the great land-masses was not the same as at the present day, a fauna of unspecialised termite genera extended over considerable portions of Australia, Africa, America, Europe, and Asia. Failing any other direct communication between the Old and New World, we must suppose that the fauna was continued to the north, even as far as Behrings Straits. To explain the distribution of termites it is necessary, as in the case of mammals, at least to assume a land-connection in this region. As the climate became colder, and the land-masses gradually approached their present contour, evolution of new species occurred, especially along the central warmer portions of the world (South America, Africa, India, and Malay Region), while north (North America, Europe and Middle Asia) and south (Australia) the remnant of the old termite fauna persisted and shrank towards the equator.

It is thus possible to explain the present distribution of termites without the assumption of a land-connection by an Antarctic continent.

According to this view, the genus *Porotermes,* which occurs in both Chili and in Australia, is to be regarded as a portion of the old cosmopolitan fauna which has persisted along the southern border of the termite area.

The relatively primitive character of the Madagascar termite fauna may be due simply to the fact that a forest country is favourable to *Calotermes,* but the condition is paralleled by the persistence in Madagascar of the ancient lemur fauna, which was largely replaced on the main-land.

VI. Conclusions.

We have seen above that, broadly speaking, the termitophile faunas of the different continents do not appear to be more closely allied to one another than the general free-living arthropod faunas. We have also observed that termitophiles are apparently scarce among the primitive, unspecialised genera of termites. It would thus appear that the termitophile faunas have mostly arisen since the present geographical separation of the termite regions has taken place. It is significant that the Æthiopian and the Indo-Malay faunas are more allied than the others, and these regions are more closely connected geographically.

When once a termitophile has become specialised and adapted to its termite host there would seem little reason why it should become further modified or disappear, and accordingly if a considerable termitophile fauna had developed prior to the present geographical separation of the regions, we should expect

some common element in all of the termitophile faunas of the world.

Such a common element is not clearly observable, and the evidence obtained from the termitophiles strengthens the view drawn from a study of the present geographical distribution of the termites themselves, namely, that the continents became separated soon after the main termite genera had become differentiated, and had passed down from the north into America, Africa, and the Indo-Malay Region. These termites produced numerous species along the tropical zone, and at the same time a termitophile fauna arose, drawn from the surrounding free-living arthropod fauna. If such a separation had not occurred soon after the main genera had become evolved, we should expect a closer affinity among the termitophiles than actually occurs. Thus the origin of the chief termite genera must be pushed backwards into such a period as when the primates passed down from the north into America and Southern Eurasia. The nature of the termite fauna of Australia, with respect to its relative paucity in species and primitive character, is in agreement with the fact that placental mammals are absent from that region, and it indicates that Australia was cut off from Eurasia at a still earlier period, when marsupials and less specialised termites were almost cosmopolitan in their distribution.

SECTION E.—ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY AND NATIVE SOCIOLOGY.

PRESIDENT OF THE SECTION:—REV. J. R. L. KINGON, M.A., F.R.S.E., F.L.S.

WEDNESDAY, JULY 9.

The President delivered the following address:—

THE TRANSITION FROM TRIBALISM TO INDIVIDUALISM.

SYNOPSIS.

I.—PRELIMINARY CONSIDERATIONS.

1. Introductory.
2. The evolution of the Native.
   - (*a*) The ideal process.
   - (*b*) The golden key.
   - (*c*) The limits set.
3. The values of the study.
   - (*a*) In moulding new policies.
   - (*b*) Obligations revealed.
   - (*c*) Suggestions made.
4. The field of enquiry.
5. The Native peoples concerned.
   - (*a*) The tribes.
   - (*b*) Their early history.
   - (*c*) Their relative positions.
   - (*d*) The reason for gradation.
   - (*e*) Dissolution of tribal bonds.
6. Processes of Native evolution.
   - (*a*) Education.
   - (*b*) Civilisation.
   - (*c*) Christianisation.

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- (*b*) Influence of missionaries
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  - Over scholars.
  - Over converts.
- (*c*) Testimonies to influence.

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Earliest conditions by horse.
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(7) Review.

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(8) Conclusions.

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Taxation and revenue.
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(*f*) The moral obligations.
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(*h*) A fitting terminus.

I.—Preliminary Considerations.

1. *Introductory.*

The accomplishment of the Union of South African States in the year 1910 A.D. was a great and notable event in South African history. The bitterness that, of necessity, had been engendered by the Anglo-Boer War made the triumph of the consummation of Union all the more notable, and conqueror and conquered were never so great as when this vision of statesmanship became an accomplished fact.

But having said this, it is essential that we should remind ourselves of a question of the first magnitude which stands across the threshold of the future, demanding the attention of the newly-formed Union. Great, undoubtedly, was the task which had for its solution the destiny of a million whites, half of them Boers, and the other half British; but what shall we say of the problem, the subject of our present study, which has for its solution the whole destiny of the seven million natives within our borders? The relative greatness of the problem is to some extent indicated by the figures already given, but the complications are many and serious. It is not too much to say that the future of South Africa, nay more, of the African continent, hangs upon the statesmanship of our handling of the Bantu during the troublous days of transition from communism to individualism.

2. *The Evolution of the Native.*

In the presence of acuter problems this one has been awaiting attention too long, and to-day the forces are in an active state of disturbed movement because their development has been, and yet is, so abnormal and erratic. In governing primitive peoples, the ideal to be held in view is to secure a steady development in all departments of the native national life, that intellectually, morally, socially, economically, and, in these days of reaction from the material to the spiritual, one may well add spiritually, there may be a steady evolution, unaccompanied by strikes, rebellions, confusion and violence, until fulness of national expression is found. That this should happen is obviously in the best interests of all concerned, not least in the best interests of the white population scattered about in small groups in the midst of an overwhelming native population. If, however, one suggests that education of the native is the golden key, it seems that there are not wanting others to raise the challenge! That there could be such a challenge in these days is surely a striking commentary; nevertheless it is the expression of a view so frequently met with in certain circles in South Africa and elsewhere that it has seemed worth while to make full enquiry into the whole situation, having special regard to the breakdown of tribalism and the development of individualism. The fact is that, view it how we will, native education cannot but proceed, and if there is adverse criticism, it may be due to the fact that we are educating on wrong lines, or to other causes, which may discover themselves in the course of enquiry.

For the purposes, then, of this study let us limit ourselves in the main to the examination of a limited area, insulated as far as possible from contact with the white races; such an area as Basutoland or the Transkeian Territories is specially suitable, inasmuch as these areas are well populated and compact, and education, by direct and indirect methods, has been carried out over a long period of years (for which statistics are available) among the rude barbarian peoples dwelling there in their primitive state. When we have seen the results of education in such a territory we shall be in a better position to form a judgment on the larger question which involves the whole Bantu population of South Africa.

3. *The Values of the Study.*

It is not too much to say, and indeed adds great importance to the present study when it is remembered, that the results of our South African experiences in relation to native education, and administration, may play a large part now that peace has been concluded, since the late German territories in South-West Africa, and in East Africa, must be governed on a reconstructed basis. German East Africa, and the adjoining Portuguese Territory, can never go back to pre-war conditions and pre-war methods of administration—that is to say, the administrative methods of Germany and Portugal respectively—and it is only to be expected that the various methods of Colonial administration will be closely examined by all responsible authorities concerned before being applied to those great areas, in order that the best may be discovered and employed. Then, further, one of the great principles which has crystallised in the great war is the right of the weaker nations to develop unhindered by a powerful neighbour, and since the great nations of the world have been in conflict over this principle it is certain, so far as there can be certainty in these affairs, that the League of Allied Nations, if, and when, it comes to be established, will not rest content with its violation in the territories of any member of the League. But the principle is capable of development, and it is not difficult to see that the permissive element must give place to obligation. It is not enough merely to refrain from hampering the development of the weaker nations: we must logically go further and shoulder our responsibilities, doing all that we can, without unduly forcing the pace, to help on their development. And when those weaker nations are within our own borders it is imperative that we should not merely govern them more or less justly and give them freedom to develop, but that we also give them every assistance to evolve. Indeed, it is the height of folly, even economically speaking, to keep a large section of any specified population poor and ignorant, for their development would in the process increase the wealth and importance of the State itself, not to mention the enhancement of values and the greater efficiency in all departments of activity. These considerations have been an added incentive to the undertaking of this study, and incidentally reveal the fact that there are interna-

tional values attaching to the effort, at the present juncture of world-politics and world-crisis. That the time is opportune for such a study will be conceded by all, and so we shall proceed on our way scrutinising our facts as we record them, and examining each principle as it emerges. One can only express the earnest hope that the emphasis laid upon certain elements in the present situation, a situation so little appreciated and understood even by men experienced in native affairs, may have the serious consideration at least of those in positions of authority in the administration of native affairs, and not (like many a Presidential address embodying the results of years of labour and the cream of a man's thought and experience) be relegated to the printed page in dust-covered binding.

On the contrary, the selection of this particular subject for the purposes of this address is designed as a stimulus to the exact study of the remarkable transition so full of extraordinary interest to the economist, the psychologist and others; and if it gives new direction to enquiry, or makes any contribution to a better understanding of the black man's handicap in the race of life, and the greater race of nations, and most of all if it imparts any elements of experience and wisdom into the policies of native administration now being formulated in the newly acquired areas already mentioned, adding sympathy and understanding to a system that in the past has been all too wooden, then its permanent value will be assured.

4. *The Field of Enquiry.*

In order, then, to have a definite basis for our enquiry, let us select as our field of investigation the Transkeian Territories. In this corner of South-Eastern Africa the author has been privileged to study the situation for himself at first hand. Bounded by the Great Kei River and the Colony proper on the west, Basutoland on the north, Natal and the Indian Ocean on the east and south, the territories consist of four well-defined areas. The Transkei proper consists of six districts extending east of the Kei River along the coastal belt as far as the Umtata River. Tembuland is composed of the six districts on the interior plateau (broadly speaking) above the coast belt, which is so well-defined a feature of the topography of South-Eastern Africa. Pondoland, the third area, inclusive of St. Johns, consists of the remote coastal districts, seven in number, which lie between the Umtata and Imzimkulu Rivers. The fourth territory occupies the remaining space, and at one time was so sparsely inhabited as to be called Nomansland in all official documents. Since, however, it was annexed in 1879* it has come to be called East Griqualand, and now supports a population of nearly 250,000 souls in eight magisterial districts.

In the accompanying Table I a clear view is given of the essential details concerning the Territory, in order that the whole of the relevant facts may be before us.

TABLE I.

Districts.	Bantu Population.	Surveyed.	Whether District Council or not.	Agricultural Land. Arable Morgen.	Pastoral Morgen.	Fallow Morgen.	Schools.	Teachers	Children in School Male.	Female.
I. **Transkei** :										
Butterworth	20,890	S	Yes	2,048	46,075	92	26	87	1,000	1,691
Idutywa	30,277	S	Yes	2,938	65,720	23	30	63	836	1,012
Kentani	36,468	..	Yes	2,536	63,792	79	43	77	1,404	924
Nqamakwe	36,652	S	Yes	3,560	74,688	64	52	159	1,719	3,153
Tsomo	20,749	S	Yes	1,730	45,915	40	44	119	1,345	2,415
Willowvale	4[illegible],321	..	Yes	3,886	78,591	31	57	136	1,894	1,777
II. **Tembuland** :										
Elliotdale	28,036	..	Yes	2,409	43,620	52	11	15	316	91
Engcobo	61,063	..	Yes	5,682	156,588	42	66	147	2,411	1,860
Mqanduli	35,183	..	Yes	4,835	73,710	42	38	62	1,087	698
St Mark's	38,438	..	Yes	3,809	68,678	133	45	108	1,413	1,591
Umtata	43,635	S	Yes	6,524	91,125	835	59	122	1,831	1,657
Xalanga	15,170	..	Yes	3,303	53,236	25	27	49	732	923
III. **East Griqualand** :										
Matatiele	36,455	..	Yes	12,778	199,028	3,194	61	183	2,375	2,875
Mount Ayliff	18,835	..	Yes	1,984	55,068	20	31	66	1,044	1,007
Mount Currie	10,581	..	Yes	25,932	290,965	6,138	13	28	375	404
Mount Fletcher	25,820	..	Yes	2,000	138,810	28	52	109	1,645	1,461
Mount Frere	37,667	..	Yes	7,232	100,350	4	73	190	1,165	637
Qumbu	33,159	..	Yes	2,816	84,312	13	69	140	1,888	2,143
Tsolo	32,646	..	Yes	3,314	95,542	302	53	118	1,795	1,806
Umzimkulu	35,603	..	Yes	8,401	169,546	1,463	61	152	2,211	2,296
IV. **Pondoland** :										
Bizana	42,366	..	No	5,117	103,791	..	18	29	400	434
Flagstaff	27,780	..	No	5,207	61,596	..	23	47	869	844
Libode	25,421	..	Yes	2,202	79,116	65	26	39	640	541
Lusikisiki	44,015	..	No	10,737	134,281	..	21	35	521	521
Ngqeleni	36,648	..	Yes	6,016	63,833	117	36	62	1,165	637
Tabankulu	37,509	..	No	11,121	66,973	33	29	52	977	857
V. **St. Johns**	17,888	..	Yes	3,466	49,220	94	12	14	330	191
	879,126			168,352	2,911,384	16,923	1,076	2,408	33,418	34,446

NOTE.—Population: All races, 908,706 Europeans, 19,660. Increase on 1904 Census = 8.7 per cent.

School returns as at June, 1919.

5. *The Native Peoples Concerned.*

At this stage it is necessary to draw attention to a remarkable fact. In the main the native population consists of Fingoes, Tembus, Pondos, and Pondomisi, though there are other smaller peoples also living in the Territories. All of these are now emerging from barbarism. The Fingoes were the first to come into contact with the white pioneers as these latter gradually pushed eastwards; and the west-flowing tides of native invasions beat upon the rock of white resistance, only to be flung back whence they came. Into the details of the conflicts as between white and black it is impossible to enter, suffice it to say that the Fingoes were refugees from various tribes cast adrift by the upheavals caused by the great Tshaka, Chief of the Amazulu, some hundred years ago. This chief, living west of Delagoa Bay, trained his hordes and fought east, west, north and south over an area of more than 100,000 square miles. From Delagoa Bay to the Griqua Country near Orange River, and from the Barutzee country in the north to that of the Amampondo on the south, was one scene of war and desolation—*i.e.*, 1820-1835, about. The Rev. Wm. Shaw, in his book, "The Story of My Mission," published in 1860, tells us that:—

> Multitudes perished by famine, while in some cases small tribes became cannibals, in consequence of the impossibility of obtaining the ordinary means of subsistence. There is reason to believe that during a period of about 18 years, terminating in 1835, not less than one-half of the entire population of the immense region described above was destroyed by these terrific native wars.

An earlier document, the petition drawn up by the Householders of the Town of Durban in 1835, and forwarded to the Governor urging the annexation of Natal, gives us a valuable insight into the conditions of affairs in Natal so far back as that date. We learn there that:

> In consequence of the exterminating wars of Chaka, late King of the Zuloos, and other causes, the whole country included between Umzimcoola and Togala Rivers is now unoccupied by its original possessors, and, with a very few exceptions, is totally uninhabited. Numbers of natives from time to time have entered this settlement (*i.e.*, Durban) for protection, the amount of whom at this present moment cannot be less than 3,000.

From these two quotations it will be gathered that there was a radical redistribution of the various native tribes concerned in this great upheaval, and the displacement of the tribes very much complicated the whole general position. Fleeing before the conqueror, the refugees were put to the necessity of fighting the peoples into whose country they had fled for sanctuary. If they were beaten off they had to try elsewhere to secure the means of subsistence, and if they were victors those over whom they had gained ascendancy were compelled in turn to fly for refuge, and in this way the Fingoes were eventually thrown up against the white man. This picture from the pages of early native history is given here designedly, for it has no slight value in relation to the rest of our study.

Broken in war, the Fingo refugees gladly availed themselves of the help of the white man against their dreaded enemies. From the first contact was established, resulting in a certain amount of mutual assistance, and eventually the Government took the Fingo people under its special protection. Since then the years have rolled on, and meanwhile the Fingoes, untrammelled by ancient custom since their tribalism was shattered, and despised and rejected by the more virile native races, have been acquiring education. Within half a century they have produced a generation of teachers without whose help the whole educational fabric, supporting an attendance of some 70,000 children in the day schools, would come perilously near collapse, for a very high percentage of the native teachers are of the despised Fingo race.

A second point which is incontrovertible is that the Pondos (and the allied Pondomisi), dwelling in the remotest districts, are by far the rawest of the Transkeian natives at the present time. It is only comparatively recently that schools have been opened in Pondoland, and there has been very little contact as between the Pondos and the white man.

A third point, which also may be accepted as authoritative, is that the Tembus occupying the less remote districts, and greater facilities in the way of education than the Pondos, undoubtedly occupy an intermediate position in the story of progress. We thus have established, for the facts are patent to all who know the peoples mentioned, that the race which had most contact with the white man, and educational facilities, is by far the most advanced of the Bantu peoples; that the race which has had least contact, and education, is by far the most barbarian; and that the Tembus, not so remotely settled, and having had some educational advantages, occupy an intermediate position. The pre-eminence of the Fingoes is all the more remarkable when we remember that they were the outcasts, the race despised and rejected of all the natives. This, however, is only a partial explanation, since the more important factor (though an unrealised one) in the situation is yet to be indicated. The Fingoes being utterly broken in war, with every vestige of tribal authority shattered, the scattered individuals threw themselves on the mercy of their neighbours, both white and black. And with the effective destruction of their tribalism, and the witchcraft that had formerly operated to bind them together and render them, like the other tribes, almost impervious to European ways and methods, their deliverance was accomplished. In their case the citadel was stormed and captured, and the individual was released from the tyrannies of tribalism and witchcraft, and in consequence, individualism asserting itself, the Fingoes developed rapidly. In the case of the Pondos and Tembus and others, however, the tribalism was not shattered at a blow, the Government being content to lay siege to the native mind by a slow process, discouraging witchcraft so far as its

open practices were concerned, and allowing the leaven of education to work. This in a nutshell explains why the other tribes are relatively less advanced. It also reveals clearly the strength of the main contention of this paper, namely, that the whole progressive movement may be accelerated in the case of the other tribes by resolutely facing and dealing wisely and directly with the belief in witchcraft, and the associated superstition concerning the ancestral spirits. The astounding thing is that this does not appear to have been recognised as yet by any of our South African writers and leaders. If it were adequately realised our missionaries would concentrate upon the breaking down of the power of witchcraft; and the Government would address themselves seriously to the task instead of assuming a mild, benevolent disapproval; and the school curriculum would include direct teaching on the subject, teaching which would influence the receptive minds of some 70,000 children every year. It were infinitely better to boldly handle the situation as suggested than to allow a continuance of the pernicious system which teaches natives to read and write and count, and leaves their minds still at the mercy of the superstitions and evils of witchcraft. If we do continue thus we need not be surprised to reap the whirlwind.

Moreover, the gradation, to which we have already drawn attention, is reflected in the various departments of national life. Statistics, where available, whether relating to educational, economic, or other matters, all tell the same tale, and the main reason is the one advanced. Proximity to the white man does much to expose the old superstitions, so that where there is most race contact we find greater emancipation from the power of witchcraft, and more disposition on the part of the "reds" to avail themselves of the education provided by the missionaries. This necessarily secures, in time, a more intelligent participation in the life and use of the public institutions of civilisation. In this way the hide-bound tribalism of this most conservative people is thrust into close juxtaposition with the intense individualism of our modern democracy, inevitably accelerating the dissolution of the ancient bonds, and issuing in a steady process, in which individual thought, action, and responsibility takes the place of communal jurisdiction. In particular we draw attention to Table I., which illustrates the point in view. There, at a glance, we see which districts have the most schools, show the greatest industry, and are, in point of fact, the most advanced. The importance of forming sound conclusions upon the evidence needs no emphasis; but the trouble is that in the past we have been content to accumulate evidence without proceeding to formulate conclusions and act upon them. Here, however, for the present, we must allow the matter to rest. We have seen that communism is doomed, the only question being as to whether we should storm the citadel or lay siege to it. If storming means the bold and resolute handling of the remnants

of witchcraft, I, for one, am all for commencing the attack. Meanwhile, however, there is no question of the continuance of the siege, and we now propose to show that, from the very nature of the case, native education cannot but proceed.

6. *Processes of Native Evolution.*

We have already indicated that native education is to proceed —indeed, more, that it cannot but proceed. But education in all its branches is the great inspiring, compelling, cause of this evolution, and it is well to realise that there are many factors in the process, and that education may flow in more than one channel. Before following up our enquiry regarding the various factors it is as well to recognise that they necessarily overlap at many points, and so are not to be regarded, as they so often are, as operating in separate spheres. Indeed, there is a continual action, reaction, and interaction going on, due to the operating of these factors, and issuing in the three great processes of Education, Civilisation, and Christianisation; and on these three buttresses the monument of progress is established.

In the first place, we see that year by year many thousands of natives are being educated, and pass from school life with a knowledge of the school work, but no adequate idea of the Christianity which brought education within their reach. In the second place, we have another great group of natives, not attending school, but coming into contact with the "School Kaffirs," or with the white officials (Police, Post Office, Railway officials, traders, and missionaries) in the Transkei; or with the white people in mining and industrial centres, on the farms, or as houseboys in the homes of the whites in different parts of the country. These natives are in a very real sense being educated, though not in the "school" sense, and so perhaps we may reasonably differentiate, and say that they are being "civilised."

Thirdly, there is the great and growing groups of Christianised natives. During the thirty-five-year period up to 1911 the native population of the Territories had a little more than doubled itself, and the number of Christian converts in the South African mission field had increased fivefold. The process of Christianisation is thus of some importance.

Reviewing the position just outlined, it is clear that one, or two, or all three processes may be directly at work in the uplift of the individual native, and that a man may be in the main the product of education alone, or of civilisation (*i.e.*, race contact) alone, or of the Christianising influences alone. Many and many of the finest members of the Christian community in Kaffirland to-day owe all that they have, and are, to the transforming touch of Christianity. People who sat in darkness saw a great light, and their ignorance was illuminated. But others, again, are, in the main, products of more than one

of these processes, and most have been influenced by all three in varying degrees, and with ever-varying result.

II.—Factors in Native Evolution.

1. *The Influence of Missions.*

(*a*) *The Product of Tribalism.*—Previously the native had been the product of the machinery of tribalism, and, as is the way of machinery, the articles produced were characterised by uniformity. In other words, the steam-roller of tribalism passing over them operated by sheer weight to reduce to a dead level those latent capacities and powers which, rightly developed, might have produced the highest results. And if we suffer to-day to any extent for the shortsightedness of our forefathers, who refrained from a resolute handling of the witchcraft that is so binding a force in tribalism, it is to be remembered as a solemn warning that those who come after us will either be blessed by the vision, and wisdom, and courage, we show, or else cursed by our blindness, and folly, and weakness. To-day, undoubtedly, we face a grave challenge. At this most critical juncture in the development of the South African natives the whole situation demands wisdom and resolution, based on sympathetic knowledge, and grave consequences are bound to follow in default of these.

Bearing in mind these considerations, we propose to review *seriatim* the various factors in the process which we see now proceeding before our eyes. In order, however, to appreciate these to the full, and to secure an all-round, understanding, view, it is necessary to indicate something of the background, as well as to trace the subsequent developments in the transition, for it is only after the ploughing, the sowing, and the growing, that we may expect to come to the harvest, and any serious study of the subject in hand would be incomplete without some outline of the conditions which produced the complex situation of to-day, and the promise of greater complications and perplexities to-morrow.

(*b*) *The Influence of Missionaries.*—Now, the first consideration that strikes the enquirer is that from the earliest times the missionary has played an important part in the raising of the native races. It is a remarkable fact, and one not usually realised, that the Government in early days actually encouraged the settlement of missionaries amongst troublesome peoples, and the chief frequently made special request that a missionary should be sent into his country. The first to be sent on this footing into Kafirland was an agent of the London Missionary Society named Williams. "For political reasons," as Professor G. E. Cory tells us,* "it was considered advisable to have some trustworthy person stationed near Gaika," and Mr. Williams was officially established in 1816, choosing for his headquarters

* "The Rise of South Africa," by Geo. E. Cory. 1, 300.

a spot on the Kat River about a mile and a half above the present town of Fort Beaufort, and some 15 miles from where Gaika was then living.

Shortly after the death of Mr. Williams, which occurred two years later, Gaika renewed his request for a resident missionary, and the Rev. John Brownlee was sent by Lord Charles Somerset, who was

> impressed with the expediency of having some discreet person living in Kaffirland, who might act as official intermediary between the Government and the Kaffir tribes, as well as of promoting Christianity and civilisation among them.*

Mr. Brownlee was paid by the Government at the rate of 1,000 rixdollars per annum, who also provided him with a waggon and oxen, and the initial expenses incidental to his establishment.

Since those days much water has flowed under the bridge, From these beginnings there has sprung the great volume of spiritual and educational achievement that has so profoundly influenced the native development; for the influence of missions underlies much, if not all, of the vast changes which have taken place so notably in the Transkei, and if, in making the appointment, Lord Charles Somerset definitely acknowledged that Mr. Brownlee's first duty was the propagation of religious instruction among the heathen, it was not very long before the Government began to support the schools, which came to be established and carried on by the various missionaries who found their way into Kaffirland. Thus in 1857 Sir George Grey gave substantial grants to certain of the educational institutions, definitely regarding such as being in the nature of an insurance against future Kaffir wars.

It is, of course, impossible to more than indicate here the lines along which the influence of missions would be most felt. That such agents as missionaries would have very great influence over the chief, and so over the people, was admitted more than a century ago, by the appointments already referred to, and the arrangements then made undoubtedly gave the natives confidence in the white man. It is no slight tribute that after a hundred years of vicissitude the missionary body retains a unique influence. But we need not be at all surprised if, in the course of the transition, some evidences of reaction against the missionaries came to be manifested. In the nature of the case, if the missionaries do their work well and faithfully some such reaction would be almost inevitable; the absence of it a sign of their impotence!

Again and again in past days the missionary has been the buffer between the Government and the natives, speaking out boldly at times against injustices, or restraining extremists by wise counsels, befriending one and another in trouble, either with the storekeeper or some petty official. Dr. C. T. Loram, in

* G. E. Cory, *op. cit.*, 1, 374.

his recent book, tells us of a certain wise old native chief, who divided Europeans into two classes, viz., white men and missionaries—a distinction of some significance.

Apart from the personal influence of individuals, there is also the very real power acquired by the teacher over his scholars. Every missionary-superintendent has a number of schools under his charge, the number varying up to as many as 40 schools in some cases. These are to be staffed with native teachers, and controlled, and the attendances would amount to as many as 1,500 children, probably more. Over most of these children the missionary would retain no slight influence as they attained years of maturity, and his advice would carry great weight with them, and over a period of years his influence would be very much enhanced in the aggregate as these large numbers of children passed through the schools. When it is remembered that over 70,000 children attend the Mission Schools of the Transkei, it will be realised how great a class of school natives is being created, and how powerfully the influence of missions is being exerted in this one sphere of activity alone.

Then, again, the bond between the missionary and those natives who identify themselves with his work by attending his services is a fairly strong one. The very fact that they have broken away from their tribalism, with its attendant heathenism, and identified themselves with the missionary counts for much. In the Union of South Africa, according to the "World's Atlas of Christian Missions," a standard work published in 1911, the number of communicants is given as 322,673; of baptised Christians, 622,098; and of native Christian adherents of all ages, some 1,145,326. It will thus be seen that in a native population of, roughly, seven millions, the direct influence of missions alone is to be reckoned with, and when we take the indirect effects into account this influence is seen to be very much greater.

(*c*) *Testimonies to Influence*.—On more than one occasion in recent years this class of school natives has been of the utmost value to the Administration in restraining unrest and preventing open rebellion. Mr. Maurice S. Evans, C.M.G., an ex-President of this section of the Association, one of the ablest and sanest of our South African writers on the Native question, regards the influence of missions as one of the three main forces acting upon the Native life. He maintains that the first is the power of custom and habit, the second being the influence exerted by the white man, with all that that has meant in the way of assuming the government and tribal disintegration, and "the third force is that exercised by the missionaries." It is not clear from the passage quoted which force he regards as exerting most influence.

Then, again, I have recently been privileged to see the manuscript of a book shortly to appear, written by the Rev William Eveleigh, and entitled "The Settlers of 1820 and

Methodism." It is a valuable contribution to the literature of this chapter in South African history in its special relation to the Wesleyan Methodist Church. His summary of the part played by the missionaries in the advancement of the Natives is worthy of a place here, and so, taking our courage in both hands, we quote:—

> We may state that the first plough seen east of the Kei River was used by a missionary at the Wesleyville Mission Station, the first store opened in Kaffraria was at Wesleyville, the first cotton grown in South Africa was on the Morley Station, the first Kaffir Grammar was written by a Wesleyan missionary at the Buntingville Station, the first waggon that the natives saw in the heart of Kaffraria was the one which brought the missionary's family, the first European type of house that was seen in the country was erected by the missionary and his helpers, the first tilled lands and gardens that native eyes looked upon in Kaffraria were those about the mission station. The first direct waggon road from Grahamstown over the Keiskamma and through the Fish River Bush into Kaffraria, which was cut and opened under the direction of the Rev. William Shaw, was symbolical of the opening of the way for the advance of civilisation into a dark heathen region. . . . . . It is said that for every £1 that goes over the Kei for missions £100 comes back to benefit commerce. 70 per cent. of the trade done by the three principal Border towns, East London, Queenstown, and Kingwilliamstown, is done with the native territories.*

In further support of the view here expressed we would appeal to the authoritative judgment expressed in the Report of the South African Native Affairs Commission, 1903-05, sections 288 and 289:—

> To the churches engaged in mission work must be given the greater measure of credit for placing systematically before the natives those higher standards of belief and conduct . . . . the weight of evidence is in favour of the improved morality of the Christian section of the community . . . . It does not seem practicable to propose any measure of material support or aid to the purely spiritual side of missionary enterprise, but the Commission recommends full recognition of the utility of the work of the churches which have undertaken the duty of evangelising the heathen, and has adopted the following resolutions:—
>
> "(*a*) The Commission is satisfied that one great element for the civilisation of the natives is to be found in Christianity.
>
> "(*b*) The Commission is of opinion that regular moral and religious instruction should be given in all native schools."

But it must not be thought that the influence of missions is the only factor in the situation. The Commission quite rightly points out that Christianity is one great element for the civilisation of the Natives, and we must now turn our attention to other elements, in order to gain an all-round view; in doing so, however, we would point out that here, at least, is the *fons et origo* of the whole great movement in the direction of progress.

2. *The Wise Restrictions of Christian Government.*

We have already indicated the significant fact that the first agent of the Government resident in Kaffirland was a missionary.

* Rev. Wm. Eveleigh in "The Settlers of 1820 and Methodism."

Too much cannot be said in praise of the Rev. J. Williams, who, at a time when the whole border was in a state of ferment, and in great fear of the natives, who were continually robbing the colonists of their cattle, not hesitating to kill any who ventured to oppose them, with supreme courage went and dwelt, with his wife and two little children, in the midst of the dreaded Kaffir hordes. Mr. Williams having died, Gaika requested, as we have already seen, that another missionary should be sent, and accordingly the second resident Government agent was the Rev. J. Brownlee. It is not possible to trace out at length, in this all too brief study, the subsequent evolution of Native administration; suffice it to say that these pioneers, admittedly working as missionaries, opened the door to progress by winning the confidence of the Natives.

Sometimes it was necessary to speak out boldly for the Native—and they did not fail to do so when occasion demanded—at other times they spoke against the evils of heathenism without shadow of compromise, and their unfailing altruism gradually commanded respect. As the whole situation developed and various officials were needed, the Government utilised the sons of these agents, the boys who had grown up amongst the natives, could think in the native way, and talk the language; and the great influence exerted by these in moulding the whole native policy over a long period of years can never be adequately estimated. As proof of the widespread influence exerted thus, it is sufficient to note some of the great and honoured names of the South African mission field, and to point out how many of their descendants occupy important positions to-day in the administration of Native affairs.

Thus we have names like Brownlee, Moffat, Schreiner, Hargreaves, Welsh, Dower, Stanford, and Warner, all of which are to-day prominent in Transkeian Administration.

With this in mind it will readily be seen that the government of the natives would tend to be strongly Christian, at least in its theoretical outlook and sympathy. When laws affecting the natives were made they would tend to uphold those views of morality and righteousness which the early missionaries had strongly insisted upon, and in any case, should the whole weight of missionary influence be declared against any particular policy or proposal, due consideration would be given to their reasonable representations, the Government recognising that none were in a better position to judge than those who worked amongst and thoroughly understood the natives.

One of the first things to be dealt with was the question of supplying liquor to the natives, and it is gratifying to find that the traditional policy has been consistently to prohibit liquor. Those who got drunk, or otherwise offended against the law, were dealt with by the Magistrate.

Ordinance No. 23 for facilitating the commerce with the Caffres, and other Nations living beyond the Boundaries of the Colony, dated 1826, provided as follows:—

"Whereas it is expedient to give increased facilities to Commerce with the Caffres and other Nations living beyond the Boundaries of this Colony, and to augment the number of Fairs, which may now legally be held within or beyond the Frontier . . . . . it shall and may be lawful for the Governor of this Colony, for the time being, to appoint Fairs, to be called 'Border Fairs,' for the purposes of Commerce with the Nations residing beyond the limits of this Colony . . . and . . . for the Dealers licensed as aforesaid, at any Border fair, to offer for Sale or Barter, any kind of Goods, Merchandise, or Cattle, which may be legally sold in this Colony: Provided always, that no Fire-Arms, or other offensive Weapons, or Ammunition of any kind whatsoever, or any Spirituous Liquors, Wines, Beer, or Ale, be offered for Sale at any such Border Fairs, such Articles being hereby declared contraband."

From such beginnings there never has been any suggestion even of looking back until within recent times the deplorable recommendation of the Select Committee on the working of the Transvaal Liquor Laws. Such a radical departure from our traditional policy would be unthinkable, for undoubtedly the policy of restriction has been all for the good of the native; and any relaxation of that restriction would have disastrous results. We would speedily reap the whirlwind.

Giving evidence on this point before the Commission already referred to, the Magistrate of Butterworth, Mr. T. W. C. Norton, said:—

> If there were no prohibition as regards liquor, many of the men who do not take liquor now would take it . . . . If it (prohibition) were removed I do not think that we, the Europeans, could live in the Territories. We would require an enormous police force." *

This expression of opinion, by no means an isolated one, coming from one who has had 28 years' residence in the Transkei, indicates the great value of this wise restriction of the Government.

A further point not unconnected with witchcraft and communism on which the Government took a firm stand, was that of prohibiting the dances held customarily on the occasions when children came of age. The Puberty Rites were not so elaborate as those of the interior tribes, but it is clear that they were the occasions of gross license, and the inculcation of dark superstitions.

The *Ukutshila* dances of the *Abakweta* (the newly-circumcised boys) were indescribably licentious, the women also taking a prominent and disgusting part in them. The *Ntonjane,* associated with the corresponding female initiatory rite, was, at least, equally bad. It was a time of feasting and immorality, during which all the girls who had arrived at the age of puberty were expected to choose paramours, and if they did not do so men were selected for them by the elder women, and they were

* Select Committee on Working of Transvaal Liquor Laws, p. 381.

forced to cohabit, to the extent of the *ukumetsha* custom, as long as the festival lasted. Dancing, feasting, and wickedness continued for a period of from seven to ten days. If anything of this kind goes on to-day (and it does to too great an extent) it is done secretly, the local magistrate turning his blind eye in that direction, and undoubtedly the wise restriction of the Government, even though loosely applied, has done much to ameliorate this appalling state of affairs.

These few notable restrictions, then, to mention no other, have made a great contribution towards the betterment of the Transkeian natives, and of that State within whose borders they dwell, and in the mere process of restriction and the consequent gaining of experience the natives have been advancing towards the responsibilities of individualism and acquiring a most valuable education, different, perhaps, from that usually associated with the schoolroom, and much more direct, but every bit as important in its immediate outcome.

3. *The Place of Witchcraft.*

Then, further, to come to the very heart of the matter, witchcraft, which is perhaps the central force of heathenism, had reigned supreme in native life from time immemorial. Closely related to, and confused with, the rudimentary elements of religion possessed by the Bantu, inextricably woven into the fabric of tribalism, witchcraft had to be broken. Through their belief in witchcraft, the natives thought that one individual could have an influence for evil over another, either through the instrumentality of evil spirits, or by enchantments, or through some animal like the baboon, the wolf, the toad, or the owl, this last being specially feared.

A sorcerer, desiring to injure another, could employ these agencies to bring about the sickness, or misfortune, or death of any individual; or disease might be made to fall upon his cattle, or it might operate to cause a drought, or a failure of crops; and, naturally, whenever any of these things occurred, a witch-doctor (*igqira*) was called in to discover the sorcerer (*umtakati*) who was bewitching his neighbour. The great thing in such cases of sorcery seemed to be to discover the charm that was working the evil, and the invariable punishment was the confiscation of property, and, usually, death. Where *every* misfortunte is explained in this way, it will be understood that such a belief would keep any population in a state of disturbance, and the Government, perhaps merely from this point of view, and little realising all that was involved, wisely insisted upon the suppression of the witch-doctors, who made their living in this way. It is, however, one thing to suppress witch-doctors, and quite another to explode witchcraft and belief therein, and in respect of this last nothing was even attempted, except, of course, such efforts as individuals cared to make from time to time.

Then, again, from the military point of view, it is clear that before an army marched off to war it was always doctored in weird and wonderful ways by the Tribal Priest, an ox being sacrificed in order to secure both the victory and the protection of the rank and file against wounds. The spirits of their ancestors were to be propitiated, if need be. In the event of misfortune the agent through whom the evilly-disposed spirits had exerted their power was to be discovered and exterminated, to prevent further trouble. They thus believed in the supernatural to the extent of the spirits of their ancestors, and of spirits good and bad, other than disembodied spirits, and behind them all some Great Being. But, in all their thought of the spirit-world, fear predominated, and for very fear innocent men were often "smelt out" and murdered, as we have already seen, and their cattle confiscated by the chief, or divided amongst his *amapakati,* or councillors; or, again, an astute witch-doctor would be unerring in "smelling out" men who had many head of cattle—it pleased the chief, and often meant a good "fee" for the doctor! And so men found that it was not safe to grow too rich, that, indeed, if his herds were increasing it was better for him to *lobola* (*i.e.*, to pay a number of cattle as dowry for a wife) for another wife.

The effect, then, of this fear of witchcraft would be to stimulate the practice of polygamy, which, viewed in its reactions upon the rate of increase of population on the one hand, or in its relation to the question of labour on the other hand, gives further interest and value to the development of this point of our enquiry. It is not generally realised that it was not the man who supported many wives by the sweat of his brow so much as the wives who supported and laboured for the man. The possession of many wives, therefore, meant a life of ease for the man, and not the least of the evils engendered by polygamy was that of idleness. On this account, on moral grounds, and in view of its relation to their belief in the ancestral spirits, polygamy, it will be seen, must go. It is one of the remaining buttresses of the unprogressive spirit. Approaching the subject from quite another point of view, we find crimes being committed in order to secure the medicines needed for the purposes of witchcraft, thus revealing anew the undesirability of its continuance. It was quite a common thing during the early Kaffir wars, after some conflict between white and black, for the rescue party to discover the mutilated bodies of the victims. Certain organs, and parts, were most highly prized by the witch-doctors as a "medicine," or an ingredient of their "medicines," for it was commonly believed that certain qualities were associated with certain organs of the body. How the belief arose will probably never be determined now, or possibly, when more is known, a connection with the belief in the ancestral spirits will be traceable. At any rate, we do know that the skin of the forehead was thought to be the

seat of perseverance, the liver was thought to be connected with bravery, the ears with intelligence, the testicles with strength, and other organs with specific qualities. If any outstanding enemy was killed, efforts were made to secure these parts, and these, when secured, were baked to cinders, pulverised, and mixed with fat and various other charms and ingredients into a paste. By using this paste the various qualities were supposed to be imparted to the participant.

Probably some similar idea operated in the reservation of the tiger's skin for the exclusive use of chiefs—and, indeed, the value placed upon members of the human body came later, when wars were ended, and Colonial Law prevented the indiscriminate taking of human life, to be associated with the corresponding parts of certain birds and animals, which were more accessible. Even as we go to print, however, the daily newspapers are recording details of the murder of an aged European tramp, which occurred in Natal in August, 1918.

> Gruesome disclosures were made during the trial [which resulted in three natives being condemned to death by the Native High Commissioner] all of which went . . . . to show that the crime arose out of witchcraft. Witnesses said they saw the head and heart of the unfortunate man cooking in a pot and that the fat was afterwards skimmed off and bottled for "muti" (medicine) to cure a young native who was always sick. Portions of the body were subsequently found by the police, and ashes of clothing were also found by the police, which went to show that the victim was fearfully mutilated first of all and then the clothing and portions of the body were either burned or buried."*

In the nature of the case the utmost reticence has been observed in printing particulars of such occurrences, and consequently not much is known, but another interesting sidelight is given by Mr. Maurice Evans in his book, "Black and White in South-East Africa." We quote from page 41:—

> At long intervals in Natal there have happened murders of white people living isolated lives among the Abantu, which, when investigated by the Courts, have disclosed the tremendous hold the belief in witchcraft has among the people, for, in nearly all cases, these killings have been to obtain medicine of peculiar virtue. More frequently murders of natives occur, weird with a tragic fascination, in which people were waylaid, killed, and their bodies subjected to dissection, to furnish the "U'muti" wanted by some doctor who can command the superstitions of the people. The court inquiries, when such are held, reveal the intimate faith still held by the Abantu in their ancestral beliefs.

For the sake of those who desire to pursue the subject further, I would mention in this connection the valuable paper on "Native Superstition in its Relation to Crime,"† read in 1916 before this Association by the Hon. Justice C. G. Jackson, in which he develops the theme with authority and precise knowledge.

Those who realise the full facts of the case will readily agree that it was a great day for Kaffirland when an enlightened

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* *E.P. Herald*, 20/9/19.

† Rept. S.A. Assn. for Adv. of Sc., Maritzburg, 1916.

Government decided to act along the lines indicated, and the wisdom of the decision has been abundantly vindicated, not only by the sound and beneficent results attained, but also by the promise of future attainment in the various departments of national achievement. Obviously, it was impossible for any Colonial Government to permit the continuance of such customs, for at any time an influential witch-doctor might launch an expedition against the scattered colonists; nor, in any case, could crime be condoned; and, accordingly, a strong attitude was assumed, forbidding these men to practise their cult. Unfortunately, however, when the particular dangers were, in the main, disposed of, the Government, instead of finishing the whole business at once, allowed the matter to drift, and so to recur and perpetuate.

But, in turning over the pages of history, and moving in the realm of events rather than customs, one is made aware of the strength of this overshadowing communism in the greater events, as well as in many and many a small incident upon which great events were hinged. Of course, every decision to make war, or conversely, to make peace, was a tribal decision. As an individual the native was closely bound by the customs of the tribe, and when it came to important matters, such as the making of laws, or the trial of an individual, or arriving at any momentous decision, then the whole matter was discussed in general council, sometimes for weeks on end, the ultimate decision being practically the finding of the meeting, or series of meetings. In this way, when eventually the chief gave his ruling, it was usually along the lines of the general consensus of opinion, and in the process of discussion, since every detail was dealt with, each individual made his contribution towards the decision, and all came to understand the whole position.

But, whatever the decision, it was the decision of the tribe, and in order to carry it out the tribe set to work as one man. The great cattle-killing delusion of 1856, which broke the power of the AmaXosa more effectively than any previous Kaffir war had done, is a terrible illustration of this tribal action. Yet the self-destruction of the AmaXosa is only one of the more obvious instances of the kind having this peculiar characteristic, that the natives embarked with deliberation upon this course. Now, in order to gauge the strength of this communism of thought and action, it is more important to see them acting instinctively, rather than deliberatively, and a careful enquiry into history affords us excellent examples of such action. We see them going out on an expedition, and we know full well what it must have meant of preparation, of discovering the will and wish of the Spirits of the Fathers, of sacrificing and doctoring, and then the armies have marched out to battle with the highest hopes and enthusiasms, until on the way some inauspicious omen was manifested. Then, in a moment, a sudden panic—and as one man the tribe fled ignominiously.

We give three illustrations, though many more might be cited. The first dates back to the Kaffir War of 1834-35, when a party of soldiers, cut off from the main body, were beset in the bush by the Kaffir hordes. Now, it so happened that one of the men had captured a crow during the course of the day, and when the shades of evening were settled over the bush he attached a blazing ember from the camp-fire to the feet of the bird. Terrified by the smoking brand, the crow, flapping its wings and scattering the sparks in all directions, and making a great noise, aroused the whole neighbourhood. Needless to say, the natives, who were lying in the bush in large numbers, awaiting the moment of attack, were quite sure that some evil spirit was flying through the night air, and accordingly fled from the scene in the moment of triumph.

The second example was enacted in the year 1850, when a large army of AmaXosa Kaffirs, having designs upon the cattle of the Fingoes, drove Lord Charles Somerset and his force of six hundred men into Fort Hare for protection. This encounter proved that they were certainly not wanting in courage. Yet a few days later, as these AmaXosas were operating between the Tyumi and Gaga Rivers, a crested hawk-eagle flew over the army, "uttering shrill, piercing shrieks." This was regarded as a bad omen. But when the army came in sight of the cattle, guarded by five or six Fingoes, and a lucky shot wounded one of their leaders, in a moment this victorious army was stricken with panic, and fled ignominiously, refusing to be rallied.

The third story still lingers as a tradition in Tsolo District, though it occurred in the Rebellion of Umhlonhlo in the year 1879. Having murdered the British Resident, Mr. Hamilton Hope, Umhlonhlo, the Pondomisi chief, was leading his army across country. The sky was absolutely clear, until the magicians descried a peculiar cloud on the horizon. It seemed, as they say, to roll upon itself, and eventually it passed across the sun. This was too much for the Pondomisi—the Spirits of the Fathers must be offended to thus come over the army in shadow at noonday, and the outcome of the expedition could only be disastrous!

Their first thought was to go to some place to offer sacrifice, and so to appease the angered spirits, and accordingly they were discussing where they should go for the purpose. In the midst of the discussion a small body of horsemen came into view unexpectedly, for they knew full well that the main body of troops was far from the scene; but the sight of these few men was quite sufficient, the whole army fled for refuge—and the rebellion was ended!

In their unguarded moments, acting instinctively, the point of view was revealed, and the tribalism asserted itself unmistakably, so that we see it to be not a communism that is merely the result of deliberate and concerted action, arranged for an

occasion, but rather a communism that is inherent, part of the very fabric of the tribal organisation, because it is the normal expression of their psychological make-up.

But this is just what is to be expected, when we remember the precise organisation of native life in other respects, for, as a matter of fact, this communism, as we shall see, runs through the whole of the laws and customs and thoughts, and even the religion, of the people.

Thus the law in all its great detail is handed down from generation to generation by men who pride themselves in mastering it. When the trial is proceeding there is perfect freedom of speech, so that at any time anyone may intervene to prevent any departure from ancient custom. But the communistic conception of the whole system is seen in the fact that the accused is, *ipso facto,* guilty unless he can prove his innocence. The head of the family, and the family in native life includes the households of sons, grandsons, sons-in-law, and others, is responsible for the conduct of all the subordinates. The whole village, indeed, has collective responsibility for all the residents, and the clan for the various villages. Every man is his brother's keeper in the eyes of the law, and consequently in the interests of the community each individual acquaints himself with all that is afoot in the neighbourhood. It is this great principle of collective responsibility upon which the spoor law is founded. In tracing stolen cattle, if the spoor led to a particular kraal, the owner was compelled to trace it elsewhere, or accept the responsibility! Moreover, the particular case is not in any sense argued on its merits. The law is really a conglomeration of precedents handed down, and the whole discussion is to determine what is the custom, and whether or not the accused was guilty of infringing the custom on the point at issue. How far this is from our conception of law, and of justice, will be at once realised, and reveals the utter inapplicability of Colonial Law to the tribal native in his tribal condition, for there is a fundamental difference between trials according to the communistic law and methods and the collective responsibility of native life and the individualistic law and highly technical procedure and individual responsibility of the Colonial Courts.

A moment's reflection will reveal the possibilities of great and frequent injustices, which are inevitable when we attempt to judge the communistically-minded native by the standards of our individualistic law—a point of view to which we shall need to revert at a later stage of this enquiry, for undoubtedly the seething unrest in certain quarters is largely the product of the misunderstandings ranging over a long period, and connected with our legal processes, which inevitably mystify the native mind, and lead to not a little injustice. Probably, if we realised how great those injustices seem to be, and actually

are, from the Native point of view, we would be amazed, and the position would be speedily remedied by common consent.

But since in Native life the tribe was the distinct entity, in order to secure unanimity and precision in the tribal life, certain customs came to be hardened, and from long usage were reverenced as "the custom of our wise fathers." In this way customs and observances bound the individual in every department of life, resulting, as we have already partly seen, in an intense communism that is little understood and still less realised, and in tracing the transition from communism to individualism it is essential to give a clearer impression of the fabric of tribalism before proceeding to unravel the separate threads. In a literal sense the tribe was everything and the individual nothing. Apart from what we have already seen, almost every action was regulated by rigid custom. From the cradle (if he had one) to the grave the individual was enslaved by ancient customs of one kind and another, so that he simply did not know what freedom meant, nor could he strike out on original lines, since certain observances and actions were prescribed for him in all the changing circumstances of life. Even yet, any transgression of the customs renders him unclean, and liable to the suspicion of witchcraft, for if he is so superior to the customs of their wise forefathers as to disregard them he must be in possession of some very strong charm indeed! Should anything untoward occur in the neighbourhood, or any misfortune befall, it must be he who is responsible, for he is the only one who does not fulfil the ancient usage, and his disobedience has angered the ancestral spirits. So they argue—and so by the very fear of witchcraft the customs and traditions tend to be maintained in their entirety.

Any man attempting to improve his conditions of life is at once suspect, even if it be by the mere planting of a tree, or the taming of a wild animal, so that no progress to a better, still less to a higher, life is possible. The truly comprehensive character of these customs will be realised when we point out some of the activities for which provision is made. Thus the daily routine to begin with is governed by custom. The men have their place and work; the women, too, have their place assigned to them in the hut, and their activities defined; the boys also have their duties and privileges quite separate and distinct from those of the girls.

In these ways there is a definite organisation regulating the whole tribe, for each keeps to his, or her, own sphere punctiliously and exclusively. Even in the more particular details of eating, drinking and fasting (which is not to be understood merely in the European sense of abstention from food), procedure in washing and bathing, the cutting of the hair, these are all precisely regulated by ancient usage. The handling of the cattle, marking and ornamenting them, are likewise provided for; also, in agricultural matters, the breaking up of virgin soil for cultivation, and

any efforts at irrigation. The building of huts, with the assistance of neighbours, is similarly regulated, and one of the huts is usually set apart for the use of strangers, who may desire hospitality overnight. Any refusal to provide hospitality when required by one of equal or higher rank would be much resented, and probably bring those who did venture to refuse into serious trouble. Then, again, in a polygamous community it is sometimes a problem to maintain the peace as between many wives, and the "wise forefathers" have justified their supposed wisdom in this direction. Associated with matters pertaining to marriage is the important *hlonipa* custom whereby daughters-in-law are cut off from all intercourse with the husband's male relations in the ascending line. Their names are not to be pronounced even mentally, and if the emphatic syllable of any one of their names occurs in any other word it is to be scrupulously avoided. In this way a large group of *hlonipa* words has come to be created, and these are commonly used as required.

Women-folk, related by blood, are allowed to enter the cattlefold—except in certain periodical eventualities—and to cross the *inkundhla,* where the cattle foregather. But strange women, or those related only by affinity to the owner of the kraal, are not allowed on any pretext to go near the cattlefold, or to cross the *inkundhla,* and that is why circuitous footpaths are always found around the back of the huts. No unauthorised persons would venture to touch the milk sac without permission —they would rather die of hunger. And so we could continue to enumerate customs relating to the cutting of timber while the crops were still green, in all probability the survival of a wise forest law in regions where timber was scarce and had to be conserved; the feast of first-fruits, chiefly observed by the Pondos, and yet subject to modification and variation in different localities; customs relating to the making of fire; and, indeed, customs in every department of life.

Were these optional in character they would have little real significance for us, but the fact is that any wilful breach of custom would result in the loss of caste, and any misfortunes occurring at that time would certainly be traced to the delinquent. The caste system of India has been rightly emphasised, but in South Africa we have an amazingly well-developed caste system, as the facts recorded above clearly and conclusively show. The only difference, so far as I can see, is that in India there are several castes presenting a distinct gradation, while in South Africa we have a single powerful caste, which reduces all to the same dead level. And as the missionaries in India are compelled to face the barrier of caste, so we in South Africa have a similar task, with this singular difference, that the problem is recognised and resolutely faced in India, whereas in this country its presence is so little suspected even by our respected leaders, that no one ever dreams of referring to it as the great obstacle to progress.

It must not, however, be thought that I am suggesting a comparison between the highly-developed caste system of India in its religious significance and that of the primitive natives of this country, for I am quite content to establish the fact that the communism of Kaffraria amounts to a rigid single-caste system, and failure to observe the customs even in their minutiæ causes the uncleanness of the individual, and consequently a loss of caste, and the displeasure of the spirits of the ancestors who are to be appeased by sacrifice.

If, therefore, we sum up the whole position anew, we find that a review of each particular custom always brings us back to the same point. The strange *uku-hlonipa* custom upon which we dwelt briefly, a custom relating to language, is really rooted and grounded in ancestor-worship. The puberty rites, with their accompaniments of the *ukutshila* and *Ntonjane* dances, for the male and female initiatory rites respectively, are likewise associated directly with ancestor-worship. So also every other custom, as well as questions of peace or war, diseases of cattle, goats, and sheep, sterility or fecundity, droughts, floods, heat, cold, famine, disease, agriculture, all these are supposed to be connected with, or profoundly affected by, the activities of the spirits.

Now customs may, and do, have a very real place and value in the organisation of tribal life, and it is a very serious problem to decide whether we should proceed on a policy of the repression of native customs, or whether we should allow them to be perpetuated. Some of these customs undoubtedly operated beneficially upon heathen life in times past, and do so still in localities where tribalism is dominant. But it does not follow that those customs should still obtain in circles where education is replacing the tribal superstitions with which the customs are so intimately associated. One such custom, that of circumcision, was referred to in this connection by the Rev. W. A. Norton, B.A., B.Litt., in his Presidential Address to this section of the Association last year. In expressing his conviction that circumcision should not be suppressed, he states:

> What has struck me is the very little valid evidence that most missionaries have to offer of the essential character and moral effect (in the wider sense) of the rites, and how very little dispassionate study is given to the matter. . . . . . Early missionaries had to make a decision before the birth of ethnology, and that they did fearlessly, according to their light, however much their own immediate success was hindered. It may be that then was the time for trenchant severance from an evil inevitable legacy of past abuse.
>
> But now, I cannot help feeling, the native suffers grievous loss of very much needed discipline through the uprooting of the landmarks of immemorial sanction, and I hope it may not be too late to save some part of the structure of what is now recognised, among serious students, as a highly respectable ethnic system, in the face of the obvious failure of the effect to Europeanise.*

Now, speaking generally, the whole position is miscon-

* Rept. S.A. Assn. for Adv. of Sc., Johannesburg (1918), pp. 112-113.

ceived. The objection is not to circumcision *qua* circumcision, for most folk are agreed that there are excellent reasons which favour a continuance of circumcision under proper conditions. Nor is it even a question of securing evidence against this or any particular custom on the ground of the abuses connected with its observance. The crux of the whole matter is simply that it is, so far as the native mind is concerned, indissolubly associated with the ancestral superstition; and that is what is wrong, from a Christian point of view, with practically all of the customs, even with those which are seemingly good in themselves. This powerful superstition, which underlies the whole tribalism, cannot be tolerated; and these customs, even though purified and cleansed of animalism and other objectionable features, would still fail either to emancipate the people from the fundamental bondage of the inherent superstition, or to give them that individualism and liberty that is the inheritance of every thinking man. According to the implicit and unanimous belief of the people, the spirits in some cases acting arbitrarily cause illness or other misfortune, because they are offended, and need to be appeased by sacrifice; in other cases, the spirits are supposed to have been worked upon by means of the charms of some sorcerer, in which case the witch-doctor sets to work to "smell out" the individual responsible for the mischief. The one accused by the witch-doctor usually paid the extreme penalty in such cases, and that without alternative. But whatever view we take the effect was always the same, namely, to secure the most rigid adherence to the minutest detail of custom. "Why did you do so?" "It is our custom." That in a nutshell explains everything. The light of reason cannot operate in heathen life—it dare not. No one would ever dream of acting according to sound reason if the custom prescribed some other course! So, then, that brings us again to the heart of the matter.

If custom and its power is broken, the change is not merely external but fundamental. It is psychological in character. The native is beginning to think, and to reason. He is no longer a part of the tribal machine, a cog of the great wheel. He is no longer a mere human animal, governed by animal impulse, he is on the way to become a man governed and controlled by an ordered mind. What is in native life from our point of view so indescribably immoral is explained when we realise that in his tribal state the native is not so much immoral as simply *non-moral*—a healthy animal, strongly sexed, human in shape, with mind unenlightened and undeveloped, and dominated by superstitious fears.

Thus do we get tribalism and individualism thrown into fierce contrast. In this pitiable condition, beset by the most unreasonable fears of supernatural powers, the victim of tyrannical slavery, struggling in the toils of this communism, always and only acting according to custom, the slightest in-

fringement of which renders him unclean, and so liable to punishment and death—such is tribalism. How profound the change to an individualism that is sound and wise and strong and clean, possessing the dynamic within, the light of reason that had been put out and now is restored!

The contrast between the two is so remarkable that we can see at a glance how great is the difficulty in the way of effecting a transition from communism to individualism; for, if provision is made for almost every possible activity in the life of the individual, and the infringement of any such provision renders the individual concerned liable to the charge of witchcraft, is it any wonder that every individual takes the utmost pains to fulfil every such observance with a super-punctilious care? And it follows naturally that the weakening of the power of the witch-doctor, whose pretensions are dependent upon the detection of even slight departures from the accepted customs, has in corresponding degree been responsible for the breaking down of native custom, a point which is not without importance for the purpose of our study, since it so intimately affects the whole trend of the psychology of the native mind. Accustomed habitually to act according to strict tribal custom, they are now set free to act as individuals, and each man is become a law unto himself, a new and strange experience for individuals, and so they have liberty to adopt new methods in various spheres of activity, and to do things according to the dictates, not of the ancestral custom, but of reason. Nevertheless, the superstition still retains much of its power. This point of view is conclusively illustrated in connection with the practice of agriculture. So long ago as 1822 the Rev. John Campbell, of the London Missionary Society, who made extensive travels in South Africa, recorded that:

> Though fond of potatoes and other European articles of food, they have not been prevailed on to raise them, because to plant such vegetables would be an alteration or an encroachment upon the old system, which they venerate as established by their wise forefathers: they suppose that by planting them they would be rendered unclean, and the falling of rain be prevented.*

Bearing this in mind, it is of no slight interest to turn to the Blue Book on Native Affairs relating to British Bechuanaland, 1910, and to read what is said there concerning the same matter. In reviewing the state of agriculture in that territory, and remarking upon the lack of progress, it says (p. 8):

> It should be borne in mind that the individual native cannot be indiscriminately blamed for this. Instances have come to light from time to time of a native who has planted trees or otherwise taken a step in advance being penalised by the chief, even to the extent of the land being allotted to someone else; and even a few such cases or the threat of such action will effectively discourage enterprise. . . . Tribal tenure is, no doubt, the root cause of much of the backwardness complained of. . . .

* "Travels in South Africa," 419-420.

Unfortunately, the writer of the report did not realise that it was not the communism in land tenure merely, but the communism in general, cemented by witchcraft, that is accountable for the unprogressive character of native life, as we have been trying to show.

It will at last be observed though, that after nearly 90 years of contact with the white man, and some 60 years' experience of the white man's education, the natives are still profoundly influenced by the traditional ideas. This, it must be emphasised, is largely due to the underlying belief in witchcraft, the binding factor of communism, which is the root-cause of everything unprogressive in native life to-day. As we have already seen, as soon as a man departed even slightly from accepted tribal custom, even to the extent of planting a tree, he became conspicuous and so an object of suspicion. If any untoward event took place, such as a sudden death, or a strange illness, or a drought, the witch-doctor, in searching for a cause, was sure to "smell out" this unhappy man. In the old days men thus smelt out were tortured until they produced the charms (and consequently many an innocent individual found it convenient to produce them at an early stage in the torture!) which had wrought the evil, and (usually) they were killed, together with their wives and children, so that the "bad seed" might be exterminated. The huts, too, were burned and the cattle confiscated by the chief. Even to-day witchcraft is still a powerful factor in native life, the chief bulwark of heathenism to be overthrown by Christian missions and the other progressive forces. Until it is wholly exploded the breakdown of tribalism on the one hand, and the general progress of the natives on the other hand, is bound to be much retarded; and with this as a serious statement of the position, it will be appreciated how great a contribution was made towards the advancement of the Natives when the Government threw all its weight on the side of the discouragement of witchcraft.

Unhappily, as those who had seen the evils of the witchcraft that obtained in the early days when first white met black passed away, and their knowledge, experience, and influence was withdrawn, a new generation of officials, and missionaries too, arose who did not (and do not) realise the issues at stake; and in consequence, instead of completing the policy of suppression, witchcraft was allowed to continue as long as it was practised in a quiet way. It is this continuance, perhaps almost one might say this revival of witchcraft, to which this paper draws attention and takes exception. It is time that it were finally ended.

Of course, various factors and influences have been at work hastening the decay of the wizard's power. Thus, since ignorance is the foundation and basis of witchcraft, education has obviously played a large part in breaking its power, even though Christian teaching has not yet replaced it, in the religious aspect of the life of the nation. Furthermore, the introduction of

Colonial Law (which is Roman-Dutch) operated adversely. This was, and is, only to be expected for a time. Cases of assaults, murders, and the like, came to be tried in the Courts of Law, and offenders were punished, and thus men were either discouraged from practising witchcraft by reason of the penalties, or else the fact that they could no longer reap the fruits in the shape of the cattle of the accused, which were usually confiscated, a course now no longer possible since injured parties could appeal to the Courts for protection, deterred them from venturing upon the old trickery. Nevertheless, the old superstitions still remain deeply ingrained. With the possible exception of rare cases of extreme old age, no person dies in the Transkei, even to-day, without his friends suspecting that some enemy has accomplished his death by means of witchcraft.

As a result of this intense communism, which had no place for even the smallest expression of individualism, the obstacles to anything in the nature of advancement were well-nigh insurmountable. But once the breach was made in the walls the city was in danger of capture, and from very small beginnings we have been privileged to see not merely the widening of the breach, but the razing of the walls.

Individualism has come to stay. The ancient conservatism of the Bantu is yielding. But, in the meantime, the natives are as the negroes of America when they were emancipated from slavery; they were quite unprepared for freedom. In the home of their master there had been no necessity to take thought for the morrow, and questions involving planning and organisation had never confronted them, so that when liberty was thrust upon them they scarcely knew how to exercise their freedom, and for a time at least their liberty proved a greater burden than their slavery had ever been.

So is it with our natives. Now that the communistic bonds are being broken, each must perforce paddle his own canoe. And in utter bewilderment they face the task, steadied only by the measure of education placed within their reach by the missionaries, leavened by that section of the people who have accepted the Christian evangel, and encouraged by the experience gained in the service of the white man. But they have yet a long, long way to go, and in their weary pilgrimage deserve our sympathy, patience, and guidance.

The full tale, however, is not yet told, and in any case must be retold from other angles, so that we pass on to other considerations with which we are concerned.

The main point for us is that very strong impetus has been given to the tendency towards individualism by the direct prohibition of these communal practices, or at least the objectionable elements in them. Prohibitions, however, only deal with the subject from an external, detached point of view, and the far more fundamental movement naturally emanates from within, in this case shewing itself unmistakably and strikingly in the tran-

sition in the tenure of the land, as well as in the other great departments of life. We therefore turn in these directions in search of further light, and from this point onward we propose to trace the developments that have been proceeding in various directions in order to shew up the transition from different angles, and at the same time to reveal the extent to which the movement towards individualism has been carried. Up to the present we have concerned ourselves in the main with the background in order to show clearly the rigidity of the tribal system; the remaining factors, however, may be regarded more in the light of foreground, since we shall be tracing the more modern development from this hidebound communism, and the effect in a general way of the reactions towards individualism.

4. *The Passing of Communal Tenure.*

The natives in their original state, before the white colonists came into conflict with them, lived a pastoral life, wandering about with their herds from place to place in search of pasturage, and cultivating small patches of garden to meet immediate needs. In this primitive state cattle, sheep, and goats represented the wealth of the native, and Kaffir corn, pumpkins, mealies, and sugar cane were to be found in the garden, which was only an after-thought, the care of the womenfolk. Through all the troublous times of early native history this arrangement was the only feasible one, for at all times the tribe must be ready to fly at a moment's notice, on the approach of a hostile force, with the precious cattle to a place of safety. The first suggestion of limitation came with the impact of the black man against the Eastward tide of white emigration, and for a long period of years the Eastern Border of the Colony was in a state of the utmost confusion due to the constant inroads of the natives. During all this time the natives returned again and again to drive off the cattle of the Colonial farmers, thousands being secured in this way; in fact, so great was the state of confusion, due to the constant alarms and to actual losses of cattle, that it was one of the main causes of the Great Trek, which began in 1833.

Into all the details of this disturbed period we do not propose here to enter. Various expedients had been tried without success, until Lord Charles Somerset built a chain of forts along the frontier at suitable intervals, so that if the natives did penetrate into the Colony and drive off cattle, it would be possible, by signalling to these distant forts, to prevent the cattle from being driven over the frontier into Kaffirland. A second line of forts was built further west, within the precincts of the Colony, and the whole establishment absorbed 1,062 soldiers, together with 42 officers. This constituted for all practical purposes an impenetrable barrier, and, as already indicated, by enforcing the Fish River Boundary, was the first real suggestion of the enclosure of the land to reach the slow-moving native mind.

Then after a time followed the extension of the Colony towards the East, and more and more of the Kaffir Territory came to be absorbed by the white man, whose influence and rule afforded the natives a new security. The nomadic tribes then found that they were able to anchor themselves to the chosen locality, and free to enjoy life without fear of hostile attack. While the women of the kraal looked after the gardens, and the sons cared for the flocks and herds, the adult males were free to go off hunting, or to spend their time in social intercourse at a neighbour's feast. If they lived on farms they were expected to help at certain seasons of the year, but even then they were free to move on to the crown lands and set up their abodes there if the work proved at all irksome to their taste. This continued for a time, until, in 1820, the settlers began to arrive, and the movement for the enclosure of the farms was commenced, when the native began to find himself constantly inconvenienced by long lines of fences stretching across the hitherto open country. The fences then shut him up to three possible courses, namely, to stay on the farm paying rent (which usually took the form of giving his labour), or to move to the Native Reserves, or to "squat" on the unalienated Crown Lands in the Colony Proper. A fourth possible course developed later, and that was to acquire or rent private property in towns or villages.

As time went on, however, the native found himself more and more cramped for space, hemmed in on all sides by fences, and confined to a limited area. Where before he had been wont to make a garden at any spot he cared to choose, cultivating that patch only once perhaps, now as the population increased he was compelled to use the same ground year in and year out. At the same time the ancient communal system of land tenure began to give way to individual tenure, and the profoundest of all the changes in native life began to take place, the passing from tribalism to individualism. Rooted and grounded in the question of land tenure, the change in that department has carried with it a transformation in other departments of native life.

Thus, to sketch the picture lightly, in ancient times the tribe was everything, the individual nothing. The chief represented the tribal spirit, and the individual had no rights apart from the tribe. The cattle ran in open pasturage, and no man ever thought of permanently enclosing his garden lot; for it is well to remember that the communal system, which dates back to time immemorial, in itself was constructed for, and by, primitive peoples, who did not wish the trouble, if indeed they had the means, of fencing their fields. In passing, perhaps, it should be noted that as the crops were maturing, the men usually constructed some sort of rough hedge, made of branches.

Their dwellings, built on a given site, were usually to be found on the ridges, which were not suitable for garden land, and often amongst the stones, or in places not readily accessible.

Their gardens occupied the good land along river banks, in

valleys, and even chosen places on the hillside, the gardens of the community being usually grouped together.

Their pasture-land included all the remaining area, where the cattle wandered at will. For mutual self-protection, regulations were framed fining severely the owner of cattle which wandered into anyone else's garden, and the gardens themselves were scrupulously protected from violation. But in any case folk were expected to make adequate arrangements for the protection of their own gardens. It would seem that the sanctity of the garden land was maintained in large measure on account of the universal fear of witchcraft, and arising out of the universal belief that one man might bewitch another, or his garden. If one were found in another's garden at any time the witchcraft cry would be raised, and the culprit would be cruelly done to death. Since no one wished to meet his death thus, each one carefully avoided trespassing on another's garden land, abstaining discreetly and as far as possible from even the appearance of evil. With this tradition so deeply rooted in the native mind, there has been little tendency to enclose, especially as under communal tenure the land does not become the possession of the individual. He is only given the right to cultivate it.

But now the tribalism that was so marked and universal a characteristic of the native social system is steadily breaking down, and the transition may be observed in all its stages in the Transkeian Territories. Contact with the white man was bound to tell in the long run, and inducements on the one hand, together with pressure on the other hand, of an economic kind, could not be resisted for ever, while all the time underneath the whole of the movement the leaven of education continued to work quietly and effectively. Slowly it was realised that the tribe no longer helped, as it used to, in the struggle for existence, and that individual effort itself was becoming more and more essential. This follows directly from the education we are giving them. It is not reasonable, for instance, to expect educated natives to continue to give allegiance to some raw, ignorant hereditary chief, just because he happens to be the chief. The change was bound to come, and now that it has come we are beginning to understand that it is profound in character. The whole movement was accelerated by the Glen Grey Act of 1894, in which provision was made for the settlement of the natives of the Glen Grey District upon the land, allotments being made to individual applicants. This experiment proved to be the beginning of great things, for the success of the scheme led to its extension by Proclamation to the Transkeian Territories (and if results count, it will yet be applied inevitably in all the Native Territories of the Union), great wisdom being shown in making the measure permissive, and applicable only to such districts as voluntarily desired to have it. This was done in anticipation of the day when large numbers of natives would be dissatisfied

with the old communal conditions and desire title to their land, and it did not come too soon. Any district desiring to have these benefits is surveyed, each holding being beaconed off and given on individual title to the applicant, on certain conditions, such as the following:—

1. The allotment cannot be transferred or alienated without the consent of Government.

2. No canteen or shop for the sale of wines, spirituous liquors, beer, or malt liquors of any description, shall at any time be kept on the land hereby granted on pain of the cancellation of this grant (Section III of Title Deed).

3. The land shall not be executable for debt.

4. The allotment shall not be subdivided or sublet.

5. In case of rebellion the land shall be liable to forfeiture.

6. If the holder be sentenced to imprisonment for not less than twelve months, or fails to beneficially occupy the allotment, it is liable to be forfeited.

The movement thus initiated proceeded at first very slowly indeed. It was, of course, only to be expected that conservative peoples, such as the Bantu are, would not be eager to adopt the new plan in respect of land, especially since from time immemorial they had held and cultivated their land under communal tenure, and the whole idea of individual titles was absolutely contrary to their genius. In such cases the only wise course is to allow the experience of others to tell, and this is what the administration has consistently done, with the result that neighbouring districts, seeing the benefits accruing from survey, are already asking of themselves for their lands to be surveyed. Butterworth, Kentani, Nqamakwe, and Tsomo, all of them Western Districts, have already been surveyed, also Umtata, which, though central, is the seat of Transkeian administration. The survey of this last-named district has only just been completed.

It will thus be realised that the transition from communal to individual tenure of lands is very gradually proceeding, since only five out of the 27 districts have accepted the change. Nevertheless, the way is being prepared for the extension of the system, and in time, no doubt, the whole of the Territories will be included. Already in the surveyed districts it is found that the survey has doubled the revenue. More alarming is the fact that in the surveyed districts, owing to the rapid increase in population, nearly all the available allotments have already been taken up, leaving small margin for the future.

With this radical departure from tribal tenure of the land other changes have been closely associated. It has had a powerful influence in the direction of breaking down tribal custom. The sanctity of garden land, which we have already seen, was largely, if not wholly, dependent upon the fear of witchcraft, is now made dependent upon Colonial Law, and trespass is now punishable in the Courts. No man can, at this

stage, gauge the far-reaching effects of the change, for it goes down to the very basis of the national organisation and psychology, this substitution of Colonial Law for the native law and custom, which is so deeply indebted to the power of witchcraft for its faithful observance. This being so, we may expect a general readjustment of native life, and thought, and conduct, to the civilised standards of the European. Such an adjustment implies the complete breaking down of native law and custom, and the rearing up of a new edifice; and since we have already shown that native law and custom is indissolubly bound up with the psychology of the native mind, the rudiments of their religion, it is clear that such change will be fundamental in character. The transition period, therefore, may well be amongst the most difficult yet experienced in all the history of our relations with the black man, a period which may well test our patience and wisdom to the uttermost, during which the native will not in the least understand—much less control—the forces at work within himself. This statement of the case will give an idea of what progress will mean, and the cost is going to be very great, for what I have stated follows inevitably upon the introduction of Colonial Law into our Native Territories. Already, by Supreme Court decision, all the laws of the Union are applicable to the Transkeian Territories, without Proclamation, a state of affairs which was distinctly not contemplated by the Act of Union, and so impossible in its outworkings as to require immediate legislation to reverse the position created by the decision. But, in any case, without a complete reversal of policy, which is in the last degree unlikely, the die is already cast, and for good or bad we are definitely embarked upon this change.

At this point we find ourselves back again in the presence of the most interesting question relating to the psychology of the native. He has always been accustomed to act communistically, and the idea is deeply ingrained into his nature. Now he must launch out into the deep, and act as an individual according to the light of reason. For these acts he must take personal responsibility, and if he breaks the law he must be tried, according to the technicalities of a law which he had no part in making, and does not in the least understand. Is it fair and just of us to expect so much? But there are other features in the situation. Associated with the change in tenure we have further the establishment of District Councils, which give the people a large share in managing their own local affairs. The General Council gives them a wider interest in the affairs of the Territory. That progress has been more rapid in this diretcion is shown by the fact that already 23 out of the 27 districts have Councils. The link connecting this development with the change in land tenure is the provision made for the people to tax themselves, and for the spending of such revenue. This taxation does not in any way affect the Government hut-tax, which is in any case col-

lected. Elsewhere,* in dealing with the results of native education, we have gone into this question more fully, so that we are content at this juncture to point out that large sums have been spent by the natives themselves upon Education and Agricultural Institutions, and an Agricultural College, and that side by side with the granting of individual title, an effort is being made to secure a better utilisation of the land by the introduction of improved methods of agriculture. Compared with the wasteful methods of the primitive native, especially in view of the rapid increase of population in a limited area, this marks a real improvement, of the highest economic importance.

But we would be failing to establish the real importance of the transition in this department of native life if we did not point out that the passing of communal tenure is only the one underlying phase of that vast change now manifesting itself in all departments of the national life, the change from communism to individualism.

5. *The Improved Communications.*

(*a*) *Earliest Conditions.*—Another factor which has played no small part in the evolution of native individualism has been the means of communication. In the earliest days the natives moving from place to place would travel on foot; and consequently, unless they set out on some cattle raiding or hunting expedition to a distant part, were content to wander in the vicinity of their kraals. On the arrival of the white man in the country the natives began to acquire the fast-moving horse, chiefly, be it said, by the long series of raids on the Eastern Frontier, which took place so far back as the days of Gaika. This made it possible for them to travel further afield. But here again the fear of witchcraft operated to some extent as a deterrent to intertribal communication, and there was not much movement on the part of individuals, men preferring to remain together in their tribes. Successive Kaffir wars, however, led to the appointment of Government agents with different tribes, and this, in conjunction with the need for having suitable roads along which troops could be sent when required, quite naturally brought about the establishment of communication and the use of the ox-waggon. Probably, in the first instance, attention was paid only to repairing the drifts across the rivers, and pathways leading to these drifts, being frequently used, would tend to become the accepted road as between place and place. As a mater of fact, when the restrictions upon trading with the natives were eventually removed, it was found that the lucrative nature of the secret trading had apparently caused development to proceed to such an extent that well-beaten tracks were in existence, penetrating to the heart of Kaffirland.

(*b*) *The Ox-Waggon.*—Then, further, in a land of great

* Rept. S.A. Assn. for Adv. of Sc., Kimberley (1914), 151-164.

distances, travelling by the slow-moving ox-waggon was a tedious and dangerous business, limited by pasturage and water.

Even a mild drought, affecting the pasturage along the road, was sufficient to discourage travelling, except as a necessity, to hamper the transport of merchandise into the Territories, or the export of wool, skins, and other products, and consequently there was little coming and going, and a sluggish, heavily-moving trade of small relative dimensions. Indeed, the whole of the commerce of the Transkei has been very seriously handicapped in the past by the difficulties of communication. Where the transport is dependent upon oxen, anything in the nature of cattle disease on a large scale, or roads ill-constructed and out of repair, or even, as we have seen, a mild drought, increased the difficulties, and caused a rise in prices, limiting substantially the flow both of exports and imports. When more than one of these factors operate at the same time the position may become extremely critical, as it did, for instance, in 1912. The East Coast fever had wrought havoc among the herds, and so the milk supply had been affected, also the ploughing. This limited the mealie harvest, and soon all the mealies stored in their pits were used, and the people were compelled to buy at the traders' stores. The traders, however, were not prepared for such a great demand. "The drought continued, and the pasturage dried up; team after team of oxen was withdrawn by poverty or death; such transport as remained was vexed and impeded by 'breaks' on the line, exigencies of dipping, the general cumber of East Coast fever regulations. Carriage rose to figures ordinarily termed prohibitive, as much as 7s. 6d. per 100 lbs. being charged for a journey of 30 miles; in places money could not secure it. As the ploughing season passed without a sign of rain, something like a panic seized upon the Natives. Traders' stores were thronged with would-be purchasers of grain; mealies sold at as much as 55s. a bag. Where money was wanting, or money could not buy, people were reduced to subsistence on roots; elsewhere they abandoned their homes for better supplied localities."

This graphic description, which occurs in the annual report of the Chief Magistrate for 1912, exactly illustrates the point. Indeed, it was this climax, in all probability, which determined the Government to remedy matters forthwith by pushing the railway on into the heart of the Territories.

(*c*) *Horse Vehicles.*—Prior to the advent of the railway all the comings and goings from the centre and the west included of necessity the formidable and even dangerous post-cart (drawn by mules usually) journey of some 200 miles to the railway at Kei Road. Usually, in the darkness of the night, the driver trusted to his horses (or mules) to avoid any obstacles and "stick to the road," but it was quite the ordinary thing for the driver to feel, by prodding with the butt of the whip, how far or how near he was to the edge of the cutting which he

could not see; or to get down and strike matches to see if the cart was still on the road, and not away out in the veld! Indeed, until less than a decade ago, persons wishing to travel from point to point in the Territories were compelled to utilise the ox-waggon or the Cape-cart—or else to walk. In the case of the natives the last alternative was the one usually adopted, and so there was not much coming and going.

(*d*) *The Railway.*—The discovery of diamonds, and gold, and coal, however, led to the building of lines of railway between these places and the coast, and once they were thus made accessible the natives began to make their way thither as labourers. This meant contact with the white man, and the earning of large sums of money, which were brought back to the Transkei or other Native Territories, and spent there. Along the Witwatersrand Reef alone there were last year (1918) some 250,000 Native labourers and 90,000 house-boys, showing what a great part the improved communications by rail plays, both in the matter of race contact, as well as economically. Probably more than £1,000,000 per annum are thus made available in the way of purchasing capacity. But, most important of all for the purposes of our study, is the educational effect upon the native mind, which the improved communications have made possible. Illustrative of this and highly suggestive is the following passage quoted from the Report of the 1903-05 South African Native Affairs Commission, section 326:—

(1) "The many thousands of Natives constantly employed on farms, railways, and public work, and in mines and workshops, are inevitably being brought under what is, in the wider sense of the word, an educational influence, and are thereby becoming more useful and productive members of the community. These occupations involve considerable travel, removal for longer or shorter periods form their home environment, and contact with civilised conditions, all of which have the effect of stimulating mental activity and widening their intellectua loutlook. It appears evident that the forces surrounding the Natives are tending more and more to bring them into the field of industry."

Into the character of this education we do not propose to enter, since it is sufficient to establish the point that railway communication, by increasing race contact, has great educational value, and operates to break down the old tribalism or communism.

In the case of the Transkei, the railway not only penetrates from the west to Umtata in the centre, but also from the Natal side communication is established as far as Kokstad. On the northern boundary the rail runs as far as Maclear, and it is hoped that it will shortly be carried on to Matatiele and even to Kokstad. Perhaps in the future we shall see a railway line running inland from Port St. Johns, and St. Johns (the only port along the Transkeian coast) a place of great commercial importance.

(*e*) *The Motor.*—But in these days developments take place so rapidly that one cannot always see far ahead. It seems but as yesterday that the motor took its place in our modern civilisation, for so recently as 1911 there were only three motors in the whole of the Territories, and yet to-day (1919) nearly every village has at least one garage, and many of the larger places have two and three garages, while even old colonists who were wont to pride themselves in their horses have betaken themselves to the speedier, if more expensive, motors, to such an extent that the Cape-carts and other horse-drawn vehicles are hardly ever seen on the roads. In this motor invasion of the Transkei we see, and foresee, an expansion of trade and an all-round speeding-up and general advancement of first importance.

It is therefore no small satisfaction to observe the increasing attention which the Transkeian Territories General Council, and the Pondoland General Council, are giving to the construction of roads and bridges. These are fundamental works of the greatest importance, for if motor traffic is to develop to any great extent, we shall need roads that are more than mere tracks across the veld, and bridges across the principal rivers, in order that traffic in the summer months may not be continually delayed and endangered by the flooding after the thunderstorms.

The development, then, of the communications by rail and by road has already exerted a profound influence in opening up the country, and by increasing the race-contact it has also made a great contribution towards the uplift of the natives. They have been emancipated in some measure from the thraldom of witchcraft and the tribalism that was on no account to be violated in any of the many points of detail, and the emancipation has come very largely by the experiences inseparable from race-contact. Verily, example is greater than mere precept, and by force of concrete example, by familiarity with flagrant violations of tribalism when working for the white man, violations that somehow did not seem to bring any special expressions of the displeasure of the spirits of the ancestors, they have surely and steadily come to loose faith in their ancient beliefs and superstitions, and the bonds of tribalism dissolving, they have ventured more and more upon individualistic lines, and reaping the rewards of individual effort, are daily being tempted further and further afield. This is abundantly manifested when we compare the Transkei of to-day with the insulated Transkei of even twenty years ago, and the change noted is, after all, but the earnest and promise of far greater developments in the future.

6. *The Economic Factor.*

From what has already been said it will be realised that the economic factor also has been operating steadily in indirect ways to bring about many of the changes to which reference has been made, and we now propose to give attention to some of the more direct effects.

Into the history of our commercial relations with the natives we cannot here enter in detail, except to focus thought for a moment on the early struggles on the Eastern Frontier.

In despair all communications with the Natives were forbidden under the Dutch régime by a proclamation of Governor van Plettenberg, dated 1778, in the hope that these quarrels as between black and white would be avoided.

Twenty-four years later, when the Cape was under British rule temporarily, Earl Macartney again forbade even the crossing of the Fish River Boundary without special permission, and in 1812, when British rule had been re-established after a further period of Dutch occupation, Sir John Cradock continued the same policy.

But the proclamation notwithstanding, a clandestine trade was carried on with the natives, for the country in those days abounded in ivory, and a fairly extensive trade seems also to have been carried on by the soldiers on garrison duty in the forts along the Border. Moreover, the red clay obtainable only at a certain place in the District of Albany seems to have been in great demand by the Kaffirs, and what were called "Clay Fairs" came to be held under the supervision of the military.

These, then, were the beginnings of a trade in which the settlers soon participated on a growing scale. The natives brought ivory, cattle, hides and gum, desiring in barter the odds and ends of "Kaffir truck," such as copper wire, hatchets, beads, buttons, the red coats of the soldier's uniform, knives, mirrors, and such-like.

From the first, however, trouble seems to have centred around the bartering of cattle, for it was found that having sold his stock, the wily native usually helped himself at the first opportunity to whatever cattle was most accessible.

Professor Cory, in describing the procedure, thus sums the matter up with keen insight, and, for those who know the natives, a fine humour:—

> Kaffirs brought cattle into the district for barter, and having received their *quid pro quo*, left for their own country, but on the way made provision for further exchange by lifting someone else's cattle, or perhaps, with the assistance of some obliging friend, recovered that which had so recently been turned into beads and buttons.

Eventually it was decided to definitely institute periodical fairs where trading could be done under strict supervision, Fort Willshire being chosen for the purpose in 1824, no one being allowed to trade there without a licence. The spelling of this name, by the way, appears to be one of the minor puzzles of our historians. At one time we read of it as Wiltshire, at other times as Willshire. Commonsense suggests the former, but the official proclamations of the Government of the Cape of Good Hope, published in 1838, compel me to adhere to the latter. Two other fairs of almost negligible importance were also attempted for a time, but Fort Willshire continued to be the great centre

for trade with the natives, until a few adventurous individuals, tempted by the profitable nature of the clandestine trade, or driven to it by the hardships they experienced at that time in making a living, began to seek permission to go into the interior for trading purposes.

The granting of licences in response to these appeals amounted to a reversal of the policy which had led to the institution of the Fort Willshire Fairs, and the adventurers were so successful that licences came in time to be freely granted for trading expeditions into Kaffirland proper. But once the itinerant traders moved throughout the country, there was no longer need for the natives to make their way with their goods to the Fort, and in consequence the fairs there came automatically to an end.

From these small beginnings the great volume of Transkeian trade has proceeded, for the enterprise of the few isolated and courageous pioneers opened the doors into Kaffraria, and through the narrow portals of adventurous Frontier life the stream of modern goods and methods passed, and no obstacle was encountered that could stop the steady flow.

In the correspondence which passed between Earl Grey and Sir Harry Smith anent the state of the Kaffir tribes, we are told that

"The funds obtained by the sale of licences for trade have been applied by the Board of Roads to the improvement of our inland communications and to other works of general utility. They amount for the present year (1848) to upwards of £1,500." (P. 75, Imperial Blue-book.)

"The chief Umhala has received his plough with much delight, and is at work, and other chiefs have made application and will be supplied. As the system continues to progress I shall endeavour so to order matters that the Kaffirs may contribute to the expense of their government; any measure of the sort, however, must not be precipitated, or it would defeat its present, as well as the ultimate great object, civilisation." (Earl Grey to Sir Harry Smith, 27th March, 1848.)

These glimpses tell us how the development was proceeding after the restrictions had been removed. As we think of the towns and villages and scattered trading stations in all the wide area of both the Ciskei and the Transkei of to-day, we are reminded of all that has been involved in the building up of the commerce of that great area. In the first report of the Board of Roads for British Kaffraria (1849) the only places mentioned as having licences were Kingwilliamstown and East London, a mission station or two, and the forts * some forty-three licences in all having been issued. In addition there were four hotel licences and sixty-four working peoples' licences, the whole revenue of the Board for the area amounting to some £2,600.

This, then, gives us some idea of the position of affairs as the trade came to take root and be established before the great eastward expansion that opened the door to the Transkei.

But in those far-off days, the main attraction for the white man was the ivory obtained by the natives from the herds of

* Viz., Forts Grey, Hare, Cox, Murray, Waterloo, White.

wild elephant which abounded in the country, also the cattle. To-day the whole centre of gravity of the native trade has changed completely, even in the most backward districts, reflecting in the character of the goods now supplied the individualism which we are tracing.

As an illustration of this, the report of the Magistrate of Ntabankulu, in Pondoland, so long ago as 1910, may be quoted:

> The progress of the people is amply evident in trade. Twenty years ago the hoe was the only agricultural implement used, now every kraal possesses its plough. In those days trade was entirely by way of barter, which is now extinct. Astonishing increases in the sale and consumption of tea, coffee, sugar, matches, soap, paraffin and other groceries, as well as in the purchase of clothing and saddles of much higher values, and of such commodities as jugs, basins, and bedsteads (single and double) point to the steady progress going on. The sale of wool in the time referred to has increased tenfold.

In that same district the number of trading stations increased in twenty years from three to twenty-four. The development of trade is, however, not only evidenced by an enormously increased volume, but also by an improvement in the quality and character of the goods, and the operation of both these factors has much enhanced values all round. One trading station changed hands at £120, sixteen years later it was sold for £900, and four years later (in 1912) it was valued by arbitrators at £2,000.

These facts as quoted are not to be regarded as wholly exceptional in character. Everywhere in the Territories one finds the same wonderful advance, and though perhaps one should admit that it is not every trading station that increases in value to the same extent as the place mentioned, yet there is no question that very considerable advances are taking place, advances affecting fully nine-tenths of the stations.

The staple industries are agriculture and stock-raising, but difficulties of transport, together with the primitive methods of agriculture, militate against the development of either a large internal or export trade, so that, as a matter of fact, barely sufficient is grown to feed the population of the territories.

In the case of stock-raising, however, considerable sums of money are made available for trade and general circulation.

Wool and hides bring into the single District of Umtata some £20,000 per annum, so that the value of the exports from the 27 districts must be very great—and practically all the wool and hides pass through the hands of the traders. The fact is that Kaffir trading is still only in its infancy. The system of barter has almost wholly given place to actual money transactions, but when the native sells his produce, he very often spends the money received for his goods almost at once. Indeed, he calculates to have just enough from the proceeds to buy what he wants, so that the whole process is not far removed from actual barter, though it is accomplished through the medium of money. The flocks and herds still constitute in the main the "bank" of the Natives, but the development of wealth in the

modern sense in the Transkei is sufficiently indicated by the significant extension of the banking system of the Union to the Territories.

Thus the Standard Bank of South Africa, the National Bank, and the African Banking Corporation are all represented in the more important towns, and the amounts handled annually are eloquent of the development accomplished and proceeding.

Further indications of the growth of wealth are to be found in the extensions of the railway system; the multiplication and the increase in value of trader's stores which are to be found dotted through the countryside at intervals of five miles, or less; the large volume of business done in all departments, Postal, Telegraphic, Money Order, Savings Bank, by the Post Offices to be found in every village; the growing revenue from taxation for Union Government purposes, in addition to the voluntary assessment, unsatisfactory in character because inelastic, and inelastic since it is a poll-tax on adult males, made by the Transkeian Territories General Council, a tax which produces some £70,000 per annum, and is spent on education and public works.

Approaching the matter from another angle, we find an enormous betterment in the actual condition of the peoples: the abandonment of the blanket smeared with red ochre for European clothing, the improvement in the class of dwelling and the better furnishing thereof, the increase in many respects of their individual wants and requirements, the increase of their flocks and herds, which has meant the development of a large and important export trade in wool and hides.

We do not, however, propose to work out in detail the growth of wealth in the Transkei, since our purpose in this study is merely to afford the contrast as between the barbarism of fifty years ago and the extraordinary advances in the economic realm made by these barbarous peoples, and so to estimate the place and value of the economic factor.

Already sufficient has been mentioned in this brief review of the position to show that the growth of wealth has been very substantial indeed, and the economic factor operating in so many different spheres must have exercised powerful influence in assisting the advancement of the Native peoples, and expediting in various ways the transition to individualism.

7. *Review.*

In the course, then, of our study of the factors operating in the evolution of the Native Peoples, and in tracing the various lines of evolution from the early days in the history of Kaffirland, we have been made abundantly aware of the fact of change. Whether that change has been wholly for good is largely a matter of opinion, and we are not so much concerned here debating the point. The fact of change, however, is particularly manifested in such fundamental respects as the breaking down

of the Native Laws and Customs, the blasting of the power of witchcraft, the changing of their very psychology, and, indeed, the whole process involved in the passing from communism to individualism.

It is too late to entertain questionings as to the wisdom or unwisdom of these profound changes, the importance of which cannot be over-estimated, for the breach in these bulwarks of native national life are by now irreparable; and, in any case, there is no possibility of drawing back, since we are finally committed to them by processes which cannot be reversed.

In the ultimate analysis it is simply a question between Truth and Ignorance; whether civilised nations dare permit a continuance of the organisation of the national life of subject peoples based upon ignorance and superstition, or whether it is not a moral duty to insist upon reorganisation on the basis of truth and justice, trusting to truth to vindicate itself in time.

Already, then, it is possible to note several main lines of modern developments emerging out of the ancient and primitive tribalism, each fundamental in character and deserving careful attention in any serious study of the process of transition Among these we would specially note:—

(1) The passing of communal tenure.
(2) The establishment of sound administration.
(3) The experiment in self-government.
(4) The beginnings of taxation.
(5) The growth of wealth.

Viewing these, either singly or together, one realises how far the movement towards individualism has actually gone, and, still more, what profound changes in Transkeian conditions are pending, since upon these hang many matters of first importance, such as, *inter alia,* the development of agriculture, commerce, improved communications, security of tenure, and the growth of wealth, all of which make such a great contribution to the contentment of peoples, and a really successful Administration. And what is so strikingly manifested in the economic realm does not by any means stand by itself and alone, for in the other departments of national life the change is every bit as real, the advancement proceeding collaterally. Indeed, of all the native areas within the Union of South Africa, the Transkeian Territories are admittedly the most advanced and the best governed, and, strangely enough, this success must be attributed largely to the policy of *laissez faire.*

The Glen Grey Act, passed in 1894 by the Cape Parliament, was extended by Proclamation to the Transkei, and, shortly after, the Anglo-Boer War so fully occupied the attention of the Government that there was apparently neither time nor disposition to interfere with Native affairs. Thereafter followed a period of great depression in South Africa, and as things slowly improved, the question of a possible Union between the

four South African Colonies made it inadvisable for any one of the Colonies concerned to introduce legislation of the kind.

In 1910 the Union was consummated, and that necessarily involved the settlement of great questions, which demanded immediate attention to the virtual exclusion of native affairs; the single attempt at legislation, the Natives Land Act of 1912, hurried through Parliament, has been a bone of contention ever since. It did not, however, affect the Transkei so much, as that is a Native Reserve, and therefore does not affect the argument. Finally, the outbreak of the European War brought to an end for the time all thoughts of passing the highly contentious Native Affairs Bill, then in prospect. Thus for nearly a quarter of a century the Glen Grey Act has been operating continuously and without interference, and to this circumstance, which is of such importance in a conservative community, not a little of the success is due.

But when we have said all this there yet remains to be discovered the great dynamic of all this new life and new national expression. The facts of the case show that the underlying, inspiring, enabling cause has been, without doubt, the education of the Native: and the consequent transition from Communism to Individualism, profound in character as it is, and affecting all departments of the national life, stands revealed as the direct result of that education.

8. *Conclusions.*

Formulating our conclusions briefly, it becomes absolutely plain that education cannot but proceed, a thesis which we set out to demonstrate and prove, not because it needs proving, but because it is well that the available evidence should be collected and co-ordinated at this stage of world history, when so many backward races are demanding attention and help.

In the first place, as it has already been shown, we dare not allow the power of witchcraft to remain unbroken, and to exercise sway within the bounds of a Christian State. Secondly, even though every native school were closed, that were of no avail to stem the tide, for the natives are being educated, in any case, by mere race-contact. Thirdly, it is the duty of the State to satisfy the aspirations, not merely of one section, but of all sections of the community. Fourthly, there is the moral peril, which makes it imperative for us to educate the native out of the animal rut, which makes vile sexual customs the well-nigh universal rule of heathen life. Fifthly, the native is an asset to be developed. Good government is an essential to such development. From the point of view of taxation and revenue it is sheer folly to leave so large a section of the community ignorant and indigent, for in direct ratio as ignorance gives place to knowledge we find commerce developing steadily, making possible increased taxation and larger returns of revenue.

Apart from these considerations, it is necessary to recognise that the native has a contribution to make in the direction of national expression, and is to be regarded as a valuable asset for that purpose also.

Sixthly, there is the moral obligation resting upon us, for morally we are bound to educate the native. It is unthinkable that the white man should remain parasitic upon the native to the extent of drawing a great revenue from native taxation, and not returning an adequate amount in grants for native education, and the many other interests and needs of the native peoples.

Finally, there is the highest obligation of all. We must never forget that our State is a Christian State, that its laws are based on Christian principles, thus admitting that the best basis is the Christian one. If, then, we are even true to our national principles, we must accept the spiritual obligation which requires us to establish our subject peoples on the best basis, and constitutes the supreme claim for native education and development. And, in any case, having broken the bonds of tribalism forever, and secured the isolation of the individual, it is essential now that the sanctions of the Christion religion should replace the scourgings and lashings of heathenism, for whatever their character, they did at least operate to organise the tribe, govern thought, and prevent hopeless confusion; and now that these are gone, even ordinary reasoning demands, in the light of experience, that the new-found freedom be steadied by the vision and dynamic of the Christian religion, and that each individual may thus strive to mould his life according to the highest ideals. Individualism of such a type would indeed be a worthy terminus in the whole great transition from communism. Bolshevism represents the inevitable alternative.

Section F.—EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY, AND STATISTICS.

President of the Section—Prof. R. Leslie, M.A., F.S.S.

FRIDAY, JULY 11.

The President delivered the following address:—

CURRENCY REGULATION.

To-day, as after the Napoleonic Wars, the regulation of banking and currency is one of the most discussed of economic problems. The opening of a mint in the Union makes it specially necessary to examine our currency system, for with the establishment of the mint it is almost inevitable that some foreign banks will establish branches here. That such a tendency exists is evident if one considers the principal causes for international movements of gold. They are as follows:—

1. *Exchange at or beyond Gold Point.*

2. *A High Discount Rate in the Importing Country.*—This may induce banks to import gold even though exchange does not favour it. Their loss on exchange is simply part of the cost involved in obtaining the gold which is the basis on which they manufacture credit. During the crisis of 1907 the banks in the United States imported large quantities of gold simply to strengthen their credit position. Similarly it has been the regular custom of the South African Banks to treat the cost of importing gold as part of their general expenses of selling loans and exchange.

3. *Preparation for Speculation on the great Stock Exchanges.*—Imports of gold increase the amount of credit which bankers can create, and thus such imports stimulate the speculative markets. Buyers know that there will be cheaper credit obtainable to carry the stock they are buying in the hope of a rise. Thus in the United States it is not unusual for the leaders of a speculative campaign to import gold, even at a loss; making their profit by unloading shares during the speculation which follows.

4. *The Creation of Currency Reserves, War and other Hoards.*—After the Agadir incident of 1911 the President of the Reichsbank bought large parcels of gold at a loss. It often happened that Berlin was paying the cost of importing gold from London when exchange was at the point at which it would have paid to export gold from Berlin, if Berlin had been a free market for gold.

5. *To Advertise the Importing Bank.*—As any of these causes may result in a movement of gold, it follows that the

opening of a mint need not result in a rise in South African exchange of the full amount of sending gold to London. Part, at least, of the cost of exporting gold will be borne by the importing country. At times exchange might even fall below par.

With the possible exception of the first cause, the rate of exchange, it is clear that the import of gold is not a passive affair. Gold, it might be said, will not so much flow out as be taken out of South Africa. Those banks which take part in international finance will either desire to enter into closer working arrangements with South African banks or will themselves open branches here. That some will adopt the latter method is almost certain, especially in view of the increase in trade between America and the Union. Another reason for the revision of our present system is the danger of unsound banks being established. That this is a real danger at the present time is shown by the methods of company promotion recently disclosed in Parlament.

So far no attempt has been made to consolidate the Banking Laws of the Union. The Banks Act (Act 7, 1917) leaves the former laws of the four provinces in force, and, in addition to legalising the issue of 10s. notes, insists only on a uniform method of stating the liabilities and assets of the Banks. In this, as in the earlier acts, the only restriction on deposit banking lies in the requirement of publicity.

As regards note issue, the only point on which there is agreement in the various laws, is that the right of issue is not limited to existing banks. A reserve in specie of one-third of the notes in circulation is required except in the Cape, where the amount of the specie reserve is left to the discretion of the banks. A further restriction appears in the limitation of the total issue to the paid-up capital of the bank, or, as in the Cape, to the paid-up capital and reserve. In place of a specie reserve the Cape requires the banks to deposit with the Treasurer Government securities to the amount of the intended issue; one-fifth of this paper reserve may consist of Treasury Bills. Issue there is further restricted by a tax of 1 per cent. per annum on the notes in circulation. Notes issued under the Cape Act are legal tender in the Cape and Rhodesia. Other issues are not legal tender. As the gold holdings of the banks against liabilities would in any case result in a gold reserve exceeding one-third of their issues, the Cape Act, requiring the deposit of Government securities, is really the most restrictive on banks which are well managed. The total note issue of South African banks at 31st December, 1918, was £6,451,107; coin and bullion held in the Union amounted to £6,851,526. In addition, coin and bullion to the amount of £2,485,401 was in hand or in transit outside the Union. Legal tender issues, subject to the deposit of securities, have increased from £1,136,786 at December, 1913, to £2,437,042 at December, 1918. Other issues increased from £1,166,969 to £4,014,065. This, however, is not entirely due to the advantage

in issuing against ordinary banking securities instead of Government securities; it is largely the result of the great difficulty in getting the forms required.

The paid-up capital and reserve funds within the Union amount to £3,745,400, outside the Union to £4,675,175, a total of £8,420,575. Thus if the Union continues to restrict notes to the amount of capital and reserves, it will soon become impossible supply the paper currency which the country requires. Shareholders are not likely to acquiesce in very great additions to reserve. I do not think, however, that this restriction is necessary to prevent overissue. Its advantage rather is that it is an inducement to increase the proportion of capital to other liabilities, which are mostly payable on short notice, and so increases the amounts which can be invested in a less fluid form than that in which a banker must keep most of his assets.

In discussing restrictions on note issues there is apt to be confusion between overissue relative to power of redemption if the bank is wound up, overissue relative to demands for immediate payment, and overissue relative to prices, *i.e.*, such an issue of paper money as will cause a rise in prices. The holding of securities will prevent overissue in the first sense provided the securities do not fall in value. But the need of maintaining immediate as against ultimate convertibility requires that a considerable part of the reserve shall be in gold. The danger of overissue relative to the general level of prices is apt to be neglected. Government issues all over the world are to-day a sufficient example of such neglect. When international trade is disorganised, when gold and commodities cannot move easily to their best markets, an overissue leading to a rise in prices is always a possibility, even though the notes are nominally convertible. Even in normal times a large industrial nation may bring about a rise in world prices by increasing its issues of convertible paper money, for the gold set free goes to other countries to form the basis for the manufacture of more credit there. But in a country such as South Africa, there is no danger of an overissue forcing up prices provided immediate convertibility is assured. Her trade, compared with that of the rest of the world, is so small that prices would continue to be determined by world forces. The gold set free would be an insignificant quantity when distributed over the rest of the world. On the other hand, if Great Britain or the United States made some currency change which enabled them to economise, and therefore to export gold, the effect in increasing the quantity of money in the rest of the gold-using world would be considerable. It is for this reason that methods of economising gold, such as the adoption of the Gold Exchange Standard, which have had no evil effects in Greece or India might not be desirable in Great Britain.

Until South African trade has increased far beyond its present level it will be sufficient if we have legislation which

prevents overissue relative to any possible demands for immediate payment. It is important that it should be recognised that the opening of a mint in the Union may greatly increase the strain on the banks' reserves. If gold only left a country because exchange favoured it the matter would be simple; only the surplus gold from the mines would go. As soon as that had been absorbed exchange would automatically fall to a point at which it did not pay to export yold. But, as has been seen, gold is often moved at a loss to its importer, who expects to find his profit in other ways. It follows that the South African banks will have to maintain reserves sufficient to meet a considerable foreign drain when foreign banks begin to purchase gold here regularly. It is not to be expected that when there is pressure for gold, they will confine their demands exactly to the new production from the mines. If we could be sure no mushroom banks would be established here it might be sufficient to rely on a continuance of the good management of the existing banks, especially as publicity of accounts has been assured by the Bank Act of 1917. But new banks are certain to appear. Their stability concerns not only depositors but the whole community. The widespread unemployment and depression in trade in England in 1908 was largely due to the bank crisis in the United States. If, through bad banking, your customers lose their purchasing power, you suffer in turn, and so do those from whom you would have purchased. I propose therefore to consider how the problem has been dealt with by other nations whose banking reserves are open to the dangers which, in lesser degree, will in future be present in South Africa.

No country can afford to leave its exchanges unregulated "All the great financial countries," Withers says, "have central banks, whose business it is to regulate the money market, except America, where they are trying hard to get one and call it by some other name." Since Withers wrote, America has also found it necessary to regulate money movements. It is sometimes thought that if a country has a gold standard the exchange will regulate itself. But before this automatic regulation comes into play some of the weaker banks might have lost so much gold that they were forced to suspend payment. In any case, exchange would be suddenly forced from the gold export to the gold import point. Frequent and sudden movements would be a serious hindrance to trade. We have avoided this till now partly through the combined action of the banks, but very largely because it was not worth while to attempt to take the small amount of gold here.

The American system is of special interest to South Africa because the Cape Bank Act is based on the earlier American system which broke down in the 1907 crisis, and had to be replaced by the Federal Reserve Law of 1913. This Act divided the United States into twelve Federal Reserve districts, in each of which a Federal Reserve Bank was established. Membership of

these banks is compulsory for national banks, and State banks have strong inducements to become members. Up to 1st January, 1919, about 900 State banks had done so. Thus the Federal Reserve system now controls about 80 per cent. of the commercial banking resources. Member banks are required to provide the capital of the reserve banks up to 6 per cent. of their capital and reserves. The public may also subscribe. As the issue of notes is one of the functions of these banks, the public, by the restriction of dividends to 6 per cent., obtain some of the advantages of Government issue, while reducing the incentive to over-issue, which is always a danger of Government paper. Half of any profits in excess of 6 per cent. go to the Government, the other half to the reserve fund until this reaches 40 per cent. of the paid-up capital. Thereafter the whole surplus goes to the Government. It may be used either to increase the gold reserve or to reduce the national debt. To unify the operations of the twelve Federal Reserve Banks a Federal Reserve Board was set up. The Secretary of the Treasury and the Comptroller of the Currency are *ex-officio* members of the Board. Five other members are appointed on the advice of the Senate. This Board not only exercises general supervision over the whole system, it also has a direct share in the management of the Federal Reserve Banks, as it appoints three of the nine directors of each. Thus one-third of the directorate of the Federal Reserve Banks represents the Government. The other directors are appointed by the member banks—three as representing the commerce, manufactures, and agriculture of the district, three as representing the banks themselves.

In the United States both the old and the new law control not only note issues but the reserve against ordinary banking liabilities, a principle which was adopted here, in a modified form, in the old Natal Bank Law of 1888. The new law in the States made the Federal Reserve Banks the sole approved reserve agents, distinguished between the reserves required against demand deposits and those subject to notice of 30 days or more, and laid down the following new schedule of minimum reserves for member banks:—

Banks Situated.	Federal Reserve System. Against Time Deposits.	Against Demand Deposits.	Former System.
Not in reserve cities	5 per cent.	12 per cent.	15 per cent.
In reserve cities ...	5 per cent.	15 per cent.	25 per cent.
In central reserve cities	5 per cent.	18 per cent.	25 per cent.

The reduction in these requirements set free reserves of about $465,000,000, or, from another aspect, greatly increased the power to manufacture credit. The Federal Reserve Banks themselves are required to keep at least a 35 per cent. reserve

against deposits, but elasticity is given to the system by giving the Board power to suspend this requirement, subject to a graduated tax upon deficiencies. The fear that the conclusion of war, or even military expenditure, might cause a great outflow of gold, led to an amendment of the Act in 1917, by which reserves against time deposits were reduced to 3 per cent., and against demand deposits to 13, 10 and 7 per cent. These amounts were to be kept wholly in the Federal Reserve Bank for the district. In the days when the United States was a debtor nation these small reserve percentages could scarcely have been regarded as a very efficient protection. Possibly they may afford safety now that she is a creditor nation and, when necessary, can sell securities, and so call in gold from foreign countries. But surely any sound bank would have kept reserves at least as great as these. If this is so, the real safeguard is the power given to the Federal Reserve Board to supervise both Federal Reserve Banks and member banks. The Board may examine their books and, in the case of Federal Reserve Banks, it may require the writing off of doubtful assets.

Two kinds of paper money are issued—Federal Reserve bank notes and Federal Reserve notes. The former were not intended to give any elasticity to the money system. They were supposed gradually to replace the existing notes issued by the national banks. In April, 1918, when it became desirable to export the reserves of silver to the East, Federal Reserve bank notes were also issued to take the place of the silver certificates. In view of present-day controversy the more important form of paper money consists of the Federal Reserve notes, the notes which are intended to give elasticity to the currency system. These notes are obligations of the United States Government. They are redeemable in gold at the Treasury, and in gold or lawful money at any Federal Reserve bank. Neither form of note, however, is classed as "lawful money" by the Federal Reserve Law. Thus neither can be used by member banks for reserve against ordinary banking deposits. The law, as amended in 1917, requires a minimum gold reserve of 40 per cent. against the Federal Reserve notes, the balance of 60 per cent. may consist either of gold or or rediscounted commercial paper. The Federal Reserve Board may suspend the gold requirements, but to prevent abuse a graduated tax is imposed according to the deficiency.

It is on the use of commercial paper as reserve that controversy mainly turns. Its advocates claim for it that it provides an elastic currency in which the note issue depends upon the demands of trade, automatically expanding and contracting according to the real requirements of the country. When trade is brisk, it is said, the notes will be increased, and when trade slackens the notes will be returned to the bank. An increase in the volume of trade requires an increase both in bills of exchange and in currency. Sir Edward Holden argues that, with the

commercial bill basis, the currency in circulation is not increased unless there has been a previous increase in the volume of goods produced. "Hence," he says, "there is no similar effect on prices consequent on an increase in currency obtained in this way, as would be the case when notes are issued against securities not representing goods, such as Treasury Bills." "When trade diminishes in volume and the total of bills of exchange outstanding is reduced, the total of notes outstanding must also automatically be reduced."

There appear to be several fallacies in Sir Edward Holden's arguments. The volume of bills is not an exact measure of the volume of production. Mr. Benson has shown the possibility of £5,000,000 or more bills running against goods whose first cost was £1,000,000. This, it may be admitted, is not probable in South Africa. In fact, the tendency here is to have book debts rather than bills of exchange. More serious is the assumption that because the total of bills is reduced when trade falls off, therefore the total of notes outstanding must also be automatically reduced. But not all bills are or could be used as note reserve. As the amount of bills always vastly exceeds the quantity of notes required, a considerable contraction in the volume of trade and in the amount of bills might take place without any "automatic" contraction of currency. The currency expands readily enough, but it does not contract automatically in the way claimed. It is not, at least on the grounds claimed, automatically elastic. It appears that the real restriction imposed by the American system is not the holding of rediscounted paper, but the necessity of a reserve of 40 per cent. in gold, or the payment of a tax if the gold reserve falls below 40 per cent. Having that regulation, it may be preferable to hold the balance in commercial paper rather than in Government securities, partly because the danger of a fall in capital values is reduced, partly because the Government has less incentive to compel or to induce overissue.

In Great Britain the Committee on Currency and Finance has recently reported on the regulation of note issues. The Committee recommended that the principle of the Bank Act of 1844 should be maintained, that the note issue—except as regards existing private issues—should be entirely in the hands of the Bank of England, and that there should be a fixed fiduciary issue beyond which notes should only be issued in exchange for gold. The 1844 Act, it was recommended, should, however, be amended so as to make provision for the issue of emergency currency in times of acute difficulty. The power given to the Bank by the Currency and Bank Notes Act, 1914, under which, subject to Treasury consent, it may temporarily issue notes in excess of the legal limit, should be continued in force. Parliament should at once be informed of such action. Profits derived from the excess issue should be surrendered by the Bank to the Exchequer; the Bank rate should be raised to a figure sufficiently high to

secure the earliest possible retirement of the excess issue. The Committee considered the proposal that increases beyond the maximum fiduciary issue should be permitted upon payment of a tax by the Bank, as in the German and American systems; but it was rejected in favour of the scheme to take over the profits of the issue. The difficulty of the tax method is simply the impracticability of fixing what should be the rate of tax until there is more certainty as to the future course of interest rates. If the tax is to act as a deterrent it must be sufficiently high to secure that no profit should accrue to the Bank. To fix a rate now would involve the danger either of permitting emergency issues when they were not required, or of restricting them when they should be made. The German system, the Committee remind us, has been criticised as lending itself "to the development of crises which more stringent safeguards might have averted altogether." "We are not clear," the Committee says, "how the arrangements recently adopted by the United States, which have not been tested by experience, will actually operate."

If South African banking conditions were to remain as they are, only minor alterations would be required in our banking law, for good banking traditions, such as the South African banks have created, are the greatest safeguard. But the opening of the Mint, as has been shown, may increase the strain on the reserves of existing banks, and must almost inevitably lead to branches of foreign banks being established here. Even those who are opposed to the regulation of ordinary banking must admit that the right of issuing notes cannot be extended to every bank which may be established here. In the two leading countries which have recently considered their currency systems we have found widely different methods of control. The United States notes are the obligations of the Government itself; in England it is proposed to go back to notes guaranteed only by the Bank of England. The former are protected by a percentage reserve of gold, the latter by a £ for £ gold reserve on issues above a certain amount. In the United States the reserve against ordinary banking liabilities is also secured by a percentage holding of gold. In England the Committee recommend continued reliance on the bank rate as the best machinery to check foreign drains when they threaten to deplete the gold reserves.

As regards the first point, by whom our paper currency should be issued, South Africa has a choice of three courses. We may permit issue by any bank, we may restrict it to existing banks, or it may be handed over to Government. Even with the small number of banks now carrying on business in the Union the want of uniformity in the notes is a serious evil in a country with a great illiterate native population; how great is shown by the ease with which some stolen Portuguese notes, worth about 2½d. were passed off as 10s. notes on the natives

in Natal. Uniformity is one of the chief requisites of paper money, and on that ground alone the right of issue should not be extended. If existing banks are allowed to retain their issues, the size and colour of each denomination of the notes should be determined by the Department of Finance. It is more doubtful whether separate issues for each Province should cease. It would certainly be more convenient for the public. It might well be argued that as the sovereign is the same in all Provinces, those who are permitted by the State to manufacture substitutes for sovereigns should be prepared to pay out sovereigns in exchange for the notes, either in Bloemfontein, Capetown, Durban, or Pretoria. What increase in the reserves would be necessary to make this possible, only the banks could estimate. Possibly, though it scarcely seems probable the increased cost of holding gold would be so great as to make issues unprofitable. Clearly it would involve enormous waste to keep sufficient gold at every branch to meet possible demands; but it might be possible to keep gold at these centres. This cost would in itself act as an additional check against over-issue. The objection to the custom of circulating notes in any Province, irrespective of their place of issue, is that in a period of expansion a larger quantity of notes may be put into circulation if the office of exchange is far distant. The surplus would not return to the banks so readily for extinction. Thus, when the period of contraction set in, there would be a greater total demand on the ultimate reserves. In a crisis the banks might insist on their right to convert the notes only at the office of issue, and the delay in conversion would aggravate the evils of a crisis. The ideal is an issue legal tender throughout the Union, and convertible on demand at one office in each Province. If this is not practicable, the notes issued in each Province should be legal tender only within that Province, and should be convertible within it.

The issue of notes by Government, directly or indirectly, would make it more practicable to have a uniform paper currency, legal tender throughout the Union, and convertible at one office in each Province. The Government need not aim at making any large profit on its note issue, and can therefore afford to keep larger reserves. It may be well to repeat that the object of a paper currency is not primarily, as is often supposed, to provide "a free loan to the public by the public," but to provide a convenient medium of exchange for the industry of the nation. State issues have been wrongly used during the war in the vain hope of obtaining a loan without someone having to pay for it. But now that this great incentive to overissue is past, it may be well to examine again the advantages of making paper money Government obligations. The chief arguments in favour of Government issues are that they ensure uniformity, that the State can afford to keep larger reserves, and that the profits from the monopoly of issue should go to the public, and not

to private banks. It is sometimes added that as coining specie is a sovereign function, so also must be the engraving of notes. But these differ in a very important way; notes are credit instruments, gold is not. To issue notes is to manufacture credit, and therefore to incur liability. In coining specie Governments incur no liability. The chief objections to State issues are (1) the need in certain circumstances of permitting banks to issue paper so as to encourage an extension of banking facilities; (2) the danger of overissue; (3) the greater knowledge which the banks have of the needs of trade. As regards the first, the establishment of branch banks throughout Scotland was greatly facilitated by the banks' right of issue, because it provided them with cheap till money for such branches. In the Cape Act the tax of 1 per cent. applies only to notes in circulation. Thus, until the notes have left the bank, and have begun to earn interest, no tax is payable on them. A restriction on banking facilities would be too high a price to pay for profits of a State issue. This is certainly a point on which the banks should be consulted before any change is made. But because the issue of notes is highly desirable for the banks, it does not follow that there must not be a Government issue. The interests of existing banks could be protected by having a uniform issue, the obligation of Government, out of which there could be paid to each bank an amount equal to their average issues in 1914, to replace the paper in circulation. The notes would be convertible, so far as the public is concerned, at the same offices and under the same conditions as the remainder of the issue. If the notes were returned to the Government in this way, it would retain the right which the public have at present of demanding gold for them at the bank through which they were issued. To make this possible a distinctive letter must be used, as is done in the United States, in front of the number on notes issued to each bank. The close contact of the banks with business conditions is a relatively small advantage if a £ for £ reserve is maintained. The note issue then becomes automatic. The real objection to Government paper money is the danger of overissue. Every writer on currency mentions the historical argument that in a great crisis Governments have not, in fact, been able to resist the temptation to overissue. But the example of England shows that in a crisis such as that produced by the present war, the mere fact that the issue is usually left to the banks will not prevent the State putting into circulation an excessive quantity of its own paper. In the Napoleonic War the Bank of England notes were depreciated. At present the Government currency in India is at a premium, not at a discount. The question is not can overissue be prevented in times of great crisis. No system can prevent that; the only check is wise statesmanship. The problem is, can the issue of Government paper be regulated in such a way in normal times that the Minister of Finance will not be able

to inflate the currency. This, however, can best be treated of in connection with the reserves.

Plans for economising gold are popular at the present day, though South Africa cannot be anxious to see the rest of the world economising in such an important product. Even in South Africa there are some who think that the gold held in reserve by the banks is money which should be used to develop South African trade. But money which is in use in ordinary times cannot be a reserve against emergencies. "There is no way of making a profit on idle capital, and money kept for reserve is idle capital; or, at any rate, capital which is productive only in an indirect way." There is only one exception to this rule, viz., when the reserve is invested in bills on a foreign market in which gold can be obtained on demand. In the case of a demand for gold for export, these bills form an additional gold reserve to meet an external drain of gold. Refusal to renew internal bills would not increase the stock of gold immediately available; it would simply intensify the crisis. The real reserve is that which makes gold available at once. As between the American system of a percentage holding and the British proposals for a £ for £ reserve above a certain amount, the latter seems preferable. The American system may be more "elastic," but its elasticity is of a sort which imposes severe stresses on trade. When gold is being withdrawn from reserves for export from England only a corresponding reduction need be made in note issues, £100 in notes for £100 in gold. But if a 40 per cent. gold reserve is required, £250 in notes must be withdrawn from circulation for every £100 of species. There is the same difficulty in the system of requiring banks to hold a fixed percentage reserve against their other liabilities. But in this case the fixed amount will only be a minimum. When the actual holdings drop near to that level, the banks will exercise caution in creating new liabilities, and will import gold. It is not an automatic safeguard in times of pressure. Its chief advantage is that it puts some restraint on the weaker banks, whose collapse might bring about a general crisis. Thus it seems that for South Africa, whether the notes are issued by banks or by the Government, it will be best to have a fixed fiduciary issue, subject to alterations as our trade grows. To begin with, it might be fixed at the average issues from 1910 to 1914. That represents the minimum amount which in any case will remain in circulation, for it was absorbed before the present rise in prices and alteration in our habits of carrying gold. For the rest of the issue a £ for £ gold reserve should be maintained, though there seems no strong reason why some part of it, say 20 per cent., should not be held in bills payable in countries in which there is a free market for gold. Those who, like myself, prefer safety to profit in note regulation, would rather have the amount held in foreign bills deducted from that part of the reserve against which Government securities are held. It then becomes a real additional gold reserve.

If reserve requirements such as these are insisted on, many of the objections to a Government issue disappear. Even Ricardo, an austere authority, insists that the public "have a direct interest that the issuers should be the State." He thinks that machinery can be constructed to curb the innate wickedness of Ministers of Finance. "The power of issuing paper money," he writes, "under the requisite checks of convertibility at the will of the holder, might be safely lodged in the hands of commissioners appointed for that special purpose, and they might be made totally independent of the control of ministers" (Principles, Chapter 27). If, however, it is decided to regulate deposit banking, existing rights might well be left to the banks as some compensation for their loss of freedom, whether that consists in requirements similar to those imposed in the United States or the adoption of the Canadian system of supervision by a Bankers' Association.

Every system of regulation has two objects—to economise gold and to avoid the evils of depreciation. From their very nature it is impossible to secure both these advantages to the full extent. Under the new conditions in South Africa we shall do better to aim at obtaining a small part of the advantages of paper money while running little risk of overissue, rather than risk depreciation to avoid the expense of an adequate gold reserve.

[This address was delivered before a premium had arisen on gold in countries with a depreciated paper currency. Present conditions make stringent regulation of note issues even more necessary.]

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

Section A.—Astronomy, Mathematics, Physics, Meteorology, Geodesy, Surveying, Engineering, Architecture, and Irrigation.

MONDAY, JULY 7.

1. Address by W. Ingham, M.I.C.E., M.I.M.M., President of the Section.
2. The water supply of Kingwilliamstown: T. G. Caink, M.I.M. and C.E.

WEDNESDAY, JULY 9.

3 The nine-points circle, a note on Feuerbach's Theorem: Rev. F. C. Kolbe, D.D., Litt.D.

THURSDAY, JULY 10.

4. South African Meteorology: types of atmospheric pressure; their duration and movements: A. G. Howard, M.S.A.
5. The training of fitter apprentices in the workshops of the Prussian-Hessian State Railways: Capt. W. J. Horne, R.G.A., A.M.I.C.E.
6. The possibilities and development of the coastal belt of South Africa: T. G. Caink, M.I.M. and C.E.
7. A short description of the public works and waterworks of East London: J. Powell, M.I.M. and C.E.
8. Star streams: H. E. Wood, M.Sc., F.R.Met.S.

Section B.—Chemistry, Geology, Metallurgy, Mineralogy, and Geography.

WEDNESDAY, JULY 9.

1. Address by H. H. Green, D.Sc., F.C.S., President of the Section.
2. A method of volumetric determination of Barium and of sulphate: J. L. B. Smith, M.Sc.

THURSDAY, JULY 10.

3. The soils of the Pretoria District: B. de C. Marchand, B.A., D.Sc.

Section C.—Botany, Bacteriology, Agriculture, and Forestry.

MONDAY, JULY 7.

1. Address by Ethel M. Doidge, M.A., D.Sc., F.L.S., President of the Section.
2. On some phytogeographical boundaries in the country between the Great Fish River and Van Stadens Mountains: Prof. S. Schonland, M.A., Ph.D., F.L.S.

WEDNESDAY, JULY 9.

3. Some notes on the distribution of the genus *Aloe* in South Africa: I. B. Pole-Evans, M.A., D.Sc., F.L.S.

THURSDAY, JULY 10.

4. The morphology of the flowers of *Salix*: Prof. C. E. Moss, M.A., D.Sc., F.L.S., F.R.G.S.

FRIDAY, JULY 11.

5. Vegetable raw products which could be produced on a large scale in the Eastern Districts of the Cape Province: Prof. S. Schonland, M.A., Ph.D., F.L.S.
6. A list of host plants of some Loranthaceæ occurring round Durban, Natal: P. A. van der Byl, M.A., D.Sc., F.L.S.
7. The ecology of the Melsetter District: C. F. M. Swynnerton, F.L.S., F.E.S., F.R.H.S.
8. A preliminary report on the veld-burning experiments at Groenkloof, Pretoria: E. P. Phillips, M.A., D.Sc., F.L.S.
9. Some native edible fleshy fruits represented in the museum of the National Herbarium, Pretoria: Miss K. A. Lansdell.
10. A note on the genus *Faurea* Harv.: J. J. Kotze, B.A., B.Sc., and E. P. Phillips, M.A., D.Sc., F.L.S.
11. The genus *Borbonia* Linn. (Leguminosæ): E. P. Phillips, M.A., D.Sc., F.L.S.
12. The order Primulines (Myrsinaceæ, Primulaceæ, and Plumbaginaceæ) as represented in the Transvaal. Miss I. Verdoorn.
13. A new apple tree canker: V. A. Putterill, M.A.
14. A brief analysis of the work of Carl Thunberg on the Proteaceæ: E. P. Phillips, M.A., D.Sc., F.L.S.
15. Three noteworthy species of plants from South Africa: E. P. Phillips, M.A., D.Sc., F.L.S.
16. The systematic position of the fungus causing root disease in sugar cane in Natal and Zululand: P. A. van der Byl, M.A., D.Sc., F.L.S.

Section D.—Zoology, Physiology, Hygiene, and Sanitary Science.

MONDAY, JULY 7.

1. Mutations and evolution: Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.

WEDNESDAY, JULY 9.

2. Physiology of respiration in some aquatic insects: S. G. Rich, M.A., B.Sc.
3. South African cercariæ: F. G. Cawston, B.A., M.D., B.C., M.R.C.S., L.R.C.P.
4. The zoological survey of South Africa from an entomological point of view: A. J. T. Janse, F.E.S.

THURSDAY, JULY 10.

5. Inheritance of callosities in the ostrich: Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.
6. Some parasitic Protozoa found in South Africa: Prof. H. B. Fantham, M.A., D.Sc., F.Z.S.
7. Reports on feeding tests carried out on various plants and fungi: D. T. Mitchell, M.R.C.V.S.
8. The effects produced on cattle by feeding on *Paspalum dilatatum* infected with a species of ergot, *Clancips paspali*: D. T. Mitchell, M.R.C.V.S.
9. The fruit-shed in relation to the control of the codling-moth: F. W. Pettey, B.A., Ph.D.
10. Insect enemies of the codling-moth in South Africa and their relation to its control: F. W. Pettey, B.A., Ph.D.
11. The length of time which *Piroplasma bigeminum* and *Anaplasma centrale* survive in citrated blood: E. M. Robinson, M.R.C.V.S.

FRIDAY, JULY 11.

12. Address by Prof. E. Warren, D.Sc., President of the Section.
13. Diffraction phenomena in films of blood cells and in surface cultures of micro-organisms: A. Pyper, M.D., L.S.A.

Section E.—Anthropology, Ethnology, Native Education, Philology, and Native Sociology.

Wednesday, July 9.

1. Address by Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S., President of the Section.
2. Witchcraft: the great opposing factor to progress: Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.
3. The place of cattle as a factor in native economic development: Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.
4. Central African folk-lore tales: Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.
5. Translation of Central African folk-lore tales: J. McLaren, M.A.
6. A place-name map and gazeteer; with some explanations: Rev. W. A. Norton, B.A., B.Litt.
7. The problem of superstition in educating natives: S. G. Rich, M.A., B.Sc.
8. Engraved stones of Kongo: Miss M. Wilman.

Thursday, July 10.

9. Suto astronomy: Rev. G. Beyer.
10. Note on a find of "Strandlooper" pottery at Dunbrody, on the Sundays River: Rev. P. Stapleton, S.J.
11. The South-West Protectorate and its native population: Rev. W. A. Norton, B.A., B.Litt.

Friday, July 11.

12. Sesuto etymologies: Part 3: Rev. W. A. Norton, B.A., B.Litt.

Section F.—Education, History, Mental Science, Political Economy, General Sociology, and Statistics.

Monday, July 7.

1. Historical research in South Africa; with special reference to the Cape Archives: C. G. Botha.
2. Completion tests for school use: S. G. Rich, M.A., B.Sc.
3. How pupils actually remember spelling: S. G. Rich, M.A., B.Sc.

Wednesday, July 9.

4. Suicide from a legal and ethical point of view: G. T. Morice, B.A., K.C.

Thursday, July 10.

5. Enquiry into the origin and derivation of certain South African place-names. II.: Rev. C. Pettman.
6. Psychical research: Prof. T. M. Forsyth, M.A., D.Phil.

Friday, July 11.

7. Address by Prof. R. Leslie, M.A., F.S.S., President of the Section.
8. Some points connected with the discovery of the Cape by Bartholomeu Dias, 1488: Rev. Canon E. B. Ford, M.A.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE,

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

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EDITORIAL.

The Journal of the Association, in this number, passes under the control of another Editor, owing to the removal of the head-quarters of the Association to Johannesburg. In taking leave, regretfully, of Dr. C. F. Juritz as Editor, the Council wishes to place on record its hearty appreciation and thanks for his long and faithful service, and trusts that he may still continue to act as one of the General Secretaries, and aid in the affairs of the Association.

Some apology is due to members of the Association for the delay in issuing the Journal. However, it may be pointed out, without wishing to make excuse, that the present times are difficult and abnormal, especially in printing. Efforts are now being made to publish the Journal more expeditiously, and to issue it to date, and contributors are asked to help in this matter by revising and returning their proofs quickly, and by carefully observing the essential instructions, few in number, regarding illustrations given on page 2 of the cover.

Communications for the Editor should, in future, be addressed to P.O. Box 1176, Johannesburg. All other communications relating to the activities of the Association should be addressed to the Assistant General Secretary, P.O. Box 6894, Johannesburg.

H. B. F.

THE VOLUMETRIC DETERMINATION OF BARIUM AND SULPHATE.

By J. L. B. Smith, M.Sc.

Read July 9, 1919.

(1) Barium.

Principle.—Excess of a standard tenth-normal K_2CrO_4 solution is added to the neutral solution of a barium salt, when $BaCrO_4$ is precipitated :—

$$BaCl_2 + K_2CrO_4 = BaCrO_4 + 2KCl.$$

The excess of K_2CrO_4 is filtered off, KI and HCl added in excess, and the liberated iodine is titrated with tenth-normal $Na_2S_2O_3$.

$$2K_2CrO_4 + 16HCl + 6KI = 10KCl + 2CrCl_3 + 3I_2$$
$$3I_2 + 6Na_2S_2O_3 = 6NaI + 3Na_2S_4O_6.$$

Procedure.—The solution of barium salt should not contain less than 0·3 per cent. or more than 1 per cent. of BaO. 50 c.c. of this solution is taken, and—

(A) If acid, finely divided pure precipitated calcium carbonate is added till there remains about $\frac{1}{4}$ gm. in the flask. Then raise to boil and allow to boil for about three minutes.

(B) If alkaline, add $\frac{N}{10}$HCl until it is slightly acid, and then proceed as from (A).

In any case, even if the barium solution is neutral, add about $\frac{1}{4}$ gm. finely divided pure precipitated $CaCO_3$ and raise to boil.

Then from a burette add slowly, with continual shaking, to the hot solution $\frac{N}{10}$ K_2CrO_4 till in excess. (About 5 c.c. in excess is best.)

Raise to boil slowly, with constant shaking, and allow to boil very gently for about two minutes.

Allow to stand for a few seconds and then filter rapidly into a clean flask. In the precipitation flask raise to boil two lots of distilled water, first 50 c.c. and secondly 25 c.c., and wash the precipitate with these, adding the washings to the filtrate.

Cool completely. Add excess of KI solution, then acidify with pure HCl (about 3 c.c. concentrated acid for every 100 c.c. of the solution), and titrate the liberated iodine with $\frac{N}{10}$ $Na_2S_2O_3$, using starch as indicator.

The K_2CrO_4 solution is prepared by dissolving a roughly weighed quantity of pure sulphate free K_2CrO_4 in sufficient distilled water to make it tenth-normal, of factor more or less 1.2. The solution should, for convenience, be given two factors: one, f_1, according to the equation—

$$2K_2CrO_4 + 16HCl + 6KI = 3I_2 + 10KCl + 2CrCl_3;$$

and another, f_2, according to the equation—

$$K_2CrO_4 + BaCl_2 = BaCrO_4 + 2KCl.$$

Then obviously $f_2 = (\frac{2}{3} f_1)$, the tenth-normal solution of $BaCl_2$ being $\left(\frac{\text{mol. weight}}{10 \times 2}\right)$ per litre.

Then if we added A c.c. of $\frac{N}{10}$ K_2CrO_4 to 50 c.c. of the barium salt solution, and we required D c.c. of $\frac{N}{10}$ $Na_2S_2O_3$ (factor = F) to remove the liberated iodine, the weight of BaO in 100 c.c. of the solution:

$$= \left[2 \times f \left(A - \frac{DF}{f_1}\right) \times \frac{7 \cdot 67}{1000}\right] \text{gm.}$$

Remark.—If iron is present in the barium solution, it should be separated by NH_4Cl and NH_4OH in excess, filtering the solution and washing the precipitate, adding the washings to the filtrate. Then proceed as given from (B).

The method gives results of close agreement, especially if the average of duplicate analyses is taken.

Working this way, in a solution of $BaCl_2$, containing ·5028 gm. Ba in 100 c.c., was found:—

1. ·5024 gm. Ba in 100 c.c.	3. ·5023 gm Ba in 100 c.c.
2. ·5022 gm. Ba in 100 c.c.	4. ·5027 gm. Ba in 100 c.c.

A sample of witherite containing, by gravimetric determination, 68·36 per cent. Ba, was found volumetrically to contain: (1) 68·25 per cent. Ba, (2) 68·26 per cent. Ba.

(2) Sulphate.

Principle.—Excess of a standard $\frac{N}{10}$ $BaCl_2$ solution is added to the neutral or acid sulphate solution, when we have—

$$BaCl_2 + K_2SO_4 = BaSO_4 + 2KCl.$$

The solution is neutralised and excess of standard $\frac{N}{10}$ K_2CrO_4 is added, when $BaCrO_4$ is precipitated—

$$K_2CrO_4 + BaCl_2 = BaCrO_4 + 2KCl.$$

The excess of K_2CrO_4 is filtered off, KI and HCl added in excess, and the liberated iodine is titrated with $\frac{N}{10}$ $Na_2S_2O_3$.

Procedure.—From a burette excess of a standard $\frac{N}{10}$ $BaCl_2$ solution is run into a measured volume of the sulphate solution.

Heat gently to about 60°C. with constant shaking, allow to stand for a few moments, and then proceed as given under Volumetric Barium from (A) to (Z).

Thus, if we took A c.c. of sulphate solution, B c.c. of $\frac{N}{10}$ $BaCl_2$ (factor $= f_3$), and D c.c of $\frac{N}{10}$ K_2CrO_4 (of factors f_1, and f_2 as shown under Volumetric Barium), and we required M c.c. of $\frac{N}{10}$ $Na_2S_2O_3$ (factor = F) to remove the liberated iodine, the weight of SO_3 in 100 c.c. of the solution—

$$= \left[\frac{100}{A} \times f_3 \left\{B - f_2\left(D - \frac{MF}{f_1}\right)\right\} \times \frac{4 \cdot 0}{1000}\right] \text{gm.}$$

Remark.—The method gives absolute results. The $BaCl_2$ solution should be standardised against the $\frac{N}{10}$ K_2CrO_4 solution, as used and described under Volumetric Barium.

If the sulphate solution contains Iron, zinc or nickel, a slight excess of Na_2CO_3 (SO_4 free) is added to it, the precipitated carbonates, etc., filtered off, washed with hot water, the washings being added to the filtrate.

Excess of HCl is added and the CO_2 boiled off; then proceed as given above.

UNIVERSITY,
STELLENBOSCH.

HISTORICAL RESEARCH IN SOUTH AFRICA: WITH SPECIAL REFERENCE TO THE CAPE ARCHIVES.

By Colin Graham Botha.

Read July 7, 1919.

If the syllabus laid down at present for the teaching of South African history in schools were compared with the curriculum of, say, two decades ago, we would see a vast difference between the present and past requirements in that subject. A generation ago it seemed that merely being able to repeat the dates of Kaffir Wars and the arrivals of Governors was synonymous with having a good knowledge of our history. This was of little avail in enabling the scholar to obtain a deeper insight into his country's history. To know the history of a nation is to know something of the people that make up that nation; to know them in their daily life, to have an insight into their manners and customs; to learn of their "ups" as well as their "downs," of their faults and failures as well as their virtues and successes; to be able to view them in their political, social, commercial, economic and ecclesiastical life. One of the aims in teaching history should be the making of good citizens, and without a knowledge of history no one can be a good citizen. Not only must the citizen know the history of his country, but he can never have a just conception of it unless he also takes into consideration the history of the countries outside it, and bears in mind the events which, in generations gone by, have aided in building up the civilization of his own native land. Ask those who learnt South African history 15 years ago whether they were taught the effects on this country of the Wars in Europe in the eighteenth century between England and Holland, or France and Holland. I feel that the answer will be a decided negative. How did the war between England and Holland in 1781, the American War of Independence, or even the French Revolution, affect South Africa? Few would be able to tell with any precision except those who have made a deep research into the matter. However, this is but one of several examples which could be mentioned to prove the necessity of knowing something of the world's doings at the time that our own country was in the making.

It would seem somewhat presumptuous for one who is unconnected with the teaching profession to express an opinion as to the teaching of history, but as this paper concerns historical research into our history, I feel that this question has some bearing on what I have to say in what follows. In teaching history we should have in mind the making of good citizens, who would

lay the foundation of a sound national life, and be inspired with high and noble aims for building up a nation able to take its place among the first nations of the world. To do this the past must be studied carefully in its political, social, economic, commercial and religious aspects. The scholar must be able to understand from his history the evolution of society and how political, economic, and social events have helped to build it up. The facts must be carefully ascertained, and both sides of the question studied, for then ignorance, from which so often prejudices arise, will be dispelled. But it is also necessary to study the contemporary history of the outside world. To-day, to obtain a full appreciation of the causes leading up to present occurrences in South Africa, we must follow events in Europe. To illustrate this point further, let us take a few simple examples from Eighteenth Century South African History. Those who have studied the question of the introduction of paper money into the Colony in 1782, and its subsequent effect upon the economic position of the country for the two generations following, will know that the War between England and Holland was the cause. This country, dependent upon the Fatherland for specie, was cut off from communication for some considerable time, and the Colonial treasury became empty. To relieve the distress, paper money was circulated and secured solely on the good faith of the Government. Several French regiments stationed here at the time, and the augmentation of Company's Soldiers, resulted in a good spending medium. Everything flourished, people bought and sold houses at high prices, built or rebuilt beautiful dwellings, which they furnished lavishly, kept large retinues of slaves, and drove in costly carriages drawn by splendidly harnessed horses. In short, they lived in high style. But the crash came, as it was bound to, when, some years later, the French troops were removed and the ordinary garrison reduced to a minimum. Again, the far-distant American War of Independence and the French Revolution became a reality to the people in South Africa when the troubles at Graaff-Reinet and Swellendam arose in 1795. As a last illustration, the final cession of the Cape to Great Britain in 1814 depended upon the events which were then most prominent in Europe.

Let us now turn our attention to the methods of obtaining information and the sources to which we can apply. Our historical information depends upon two factors, namely, the material and the investigator. It is on these two points that I intend chiefly to dwell in this paper. In working out the present, we must know what has gone before. Each generation sees an advance in one way or another, and it is often by reviewing the past that we are able to steer our course in a safer direction. The essence of the good things of the past can be a great help in shaping the present. Now, we have the material at our hand to realise all this if only we could find the diggers who, for the

love of the labour and of the truth, will delve into our most precious mines of information, of which we should all be justly proud. Among a country's richest treasures are its Archives, and as a national asset, they are ever increasing in value as the generations pass by. In them we are able to read the life of the nation, and by them we should be able to dispel all prejudices and misunderstandings. They should thus be an aid in binding together the forces that go to make a strong and healthy nation. Through them we obtain a view of the ideals and hopes of the people of long ago. Through them we can recreate the picture of bygone ages, and in imagination re-live the life, share the sorrows, and engage in the social pastimes and customs of our forefathers. If, then, they are of such importance, it is fit and proper that they should be preserved for present and future generations. In South Africa we are the proud possessors of a collection of Archives which compares favourably with the records of any other country. When the history of their preservation in early days is read it is right to say that it is a matter for congratulation that they are so complete. It is certainly a matter of surprise, when the history of other Archives is compared, to find so many of the Cape records still in existence, for fire, water, war, and age have caused irreparable loss to the muniments of European countries. The words said of the Archives of England, that " they afford the most pure and ample sources of history, the best evidence of the progress of civilization, of the growth of institutions, and of the manners and customs of the country," can with truth be applied to the Cape Archives!

The most important sources for the early history of South Africa are contained in the Cape Archives in Cape Town. Of the other three Provinces of the Union, those of the Transvaal dating from 1839 are centred at Pretoria, of Natal from 1845 at Pietermaritzburg, and of the Orange Free State at Bloemfontein. I intend dealing specially with the Cape Archives. They cover a period of more than two and a half centuries, namely, from 1652 to 1910, and embrace the official papers of the Cape Colony. To understand the early history of the other Provinces of the Union, it is necessary to make full use of them. They comprise a variety of classes of records too numerous to mention, but a broad survey of them will indicate their great value. Amongst the most important series are the despatches received by and sent from the Cape and Europe during such periods as the days of the Dutch East India Company, the first British occupation from 1795, the régime of the Batavian Republic from 1803, and finally the second British occupation since 1806. The debates and resolutions of the two Dutch periods and the various annexures to the above records are of great value to the student. The reports of Commissioners cannot under any circumstances be ignored. The early records of the Court of Justice up to 1828, of the various local Government institutions, Departmental

and Magisterial correspondence, various instructions and commissions, are all documents of use. After 1806 there are Letters Patent, Commissions, Royal Warrants and Instructions, Treaties with Natives, Conventions, and maps and charts. All these are an aid to the investigator. As a subsidiary aid, there are Blue Books, Imperial Books on South African affairs, and the Cape Parliamentary Blue Books, some of which are invaluable. The writings and impressions of travellers and sojourners at the Cape will give us an idea of the observer's point of view, while innumerable pamphlets on all subjects and phases of life that are of any historical interest to any section of South Africans will be found in abundance in that magnificent collection of South African books in the Public Library at Cape Town. These must be compared with the official records as far as possible in order to verify their accuracy. Happily for the present generation, nearly half a century ago, the Colonial Government saw the value of the very early records, and took steps to preserve them for the people and for those who have to make researches. Until 1811 they had found a home in the Castle of Good Hope, when they were removed to the Public Offices, then being opened in the old Slave Lodge, which had been partly converted into offices. With one or two more removals, they were rescued from one of the Judge's Chambers in the Supreme Court Buildings (formerly the old Slave Lodge). From time to time important additions from the other Government records have been made. The preservation of a country's records is of the utmost importance, and this should be the first step towards obtaining material from which the historical student is to construct a just and unbiassed account of his country.

But there is yet another source of material which should not escape our attention. I refer to the papers to be found in private hands. In South Africa there are no muniment rooms in old family residences, such as are to be found in England. There are no well-known private collections of papers of a purely personal type. Yet there are families and individuals who possess some old diary, cash ledger, or collection of letters, or maybe some similar class of record which would prove invaluable to the enquirer in finding out something of the inner life of the people. Amongst the records of the Orphan Chamber, in the Cape Archives, are to be found most interesting and priceless papers which once belonged to private persons. Here is a bundle of receipts for money expended on clothes, food, luxuries and daily necessities; there is a ledger kept by a merchant informing us what his stock was and recording his daily sales. Here is a letter written by this merchant ordering his wares from Holland or the East Indies, and there is a Day Book kept by a farmer showing in detail his income and expenditure. A diary of a voyage to the Cape in 1798 tells us of life on an East Indiaman, and bills sent in by the doctor, the undertaker, and the dealer who supplied the provender for the burial feast, give

us some clue to the social life of the people. Picking up a private memorandum book, which was meant for no other eyes but the owner, we see him as the love-sick swain who leaves his Fatherland to seek his future in the Indies. He fills his booklet on this and that page with love phrases in Latin. Another pocket-book contains addresses of relatives and friends in Holland, a number of medical recipes, advice on several subjects, and extracts of some startling incident from the European papers.

Ah! here is a large sheet of primitive-looking black court plaster fastened to one of the leaves of this book. Enough! This little glimpse into the musty remains of the past is sufficient to reveal to us living individuals, imbued with the same passions and emotions, the same virtues and vices, the same lovable and irritating qualities as may be observed in those about us. By far the most historically valuable of these personal papers is the diary of Adam Tas of 1705, published a few years back. This document has shed much light on a controversial episode in the history of South Africa, and is one of those which should certainly not be overlooked by the earnest student.

Having been satisfied that we are fully equipped with the material, we look to the next important factor in connection with our historical research, the investigator. He is one of the most important factors in the compilation of our history. Without him, we would be like a man who, wishing to build himself a house, has all the necessary material for the same, but has not the slightest conception how to handle a trowel or hammer. The researcher must be one with an unprejudiced mind, a fair sense of proportion of things, able to sift and analyse his material. He must take up his work for the love of it and be possessed with, may I say, an unlimited amount of patience and a strong constitution for work. The pleasures of the researcher into the records are only known to those who have had the privilege of delving into the many volumes to be found in any archives. He certainly has his hopes and deep disappointments in carrying out his work, but, more often than not, his most minute success in tracing any train of inquiry is compensation enough for the more frequent disappointments. Sometimes it happens that one who would like to carry out research work is unable to do so as he lives hundreds of miles away from the centre in which the records are kept. In South Africa we have had three indefatigable workers in our Archives—Moodie, Theal, and Leibbrandt—who have published the results of their investigations in "The Records," "Records of Cape Colony," "Important Historical Documents," and "Précis of Certain Sections of the Archives." These are all an aid to such a person. The Dominion Archivist and Keeper of the Records, in his report on the Canadian Archives for 1904, said: "The true history of men, of their motives, and of their influence on the progress of this great country, which is now beginning to take its proper place, can be

fully appreciated only in the light of documents which at present, to the great majority, are unknown." To some extent this is true as far as South Africa is concerned, but, through the aid of the above gentlemen, we have been able to gain an insight into some of the documents. Yet much remains to be done. There is scope for all those who take a pleasure in the work and feel it a duty to take up the subject. The field is wide, and can sustain many workers, each of whom will take his allotment, dig it up, and bring forth the fruits for the benefit of mankind.

Coming to the last decade, it is interesting to see what has been done. The Cape Archives has become more than ever the hunting-ground of the professor and the student. Every year sees an increase in interest and number of workers. While some are using the result of their investigations for magazine articles, monographs, etc., others are seriously attempting to unravel several of the problems of our early history. This is the generation of monograph writing, and much good work can be done in this direction. If each student takes up a particular period of our history and collaborates with his co-workers, a great advance will be made in the enlightenment of the nation as a whole on many points which are yet obscure. Within recent years essays and lectures have appeared dealing with the social life of the people, legal constitution, economic questions, and other matters which indicate a real interest in the early history of the past. The publications dealing with the lives and doings of the voortrekkers, the pioneers of the late Northern Republics, have shown us how much we have still to know. The material is here, and so is the opportunity. Since the old Cape University required research to be made in the Archives by a student in order to obtain his degree in history, a number have been obliged to come to the Record Office to attain this end. It has now come to be recognised that the Archives is a centre to which all must wend their way to learn and understand properly our past history. In Cape Town, close to which are two Universities of the Union, a school of history can be developed, for the material is at hand, but it requires the aid of scholars to assist in expanding the same. If workers could be obtained in greater numbers it would be well to divide the work. The men bent on economic questions, constitutional history, ecclesiastical matters, social life and other kindred subjects which go to make up history, could each take their special lines, and so give the world the benefit of their labours. From the record kept of the people who have made use of the Cape Archives since 1912 one pleasing feature is evident, *i.e.*, that there is a steady increase in the use made of the records. This applies also to the number of those who visit the Archives to inspect some of the old and valuable papers in the show cases, and includes people of every walk in life within and without the Union. All this is a strong indication of an aroused interest in our national muniments. But of

the more serious students, more than 35 per cent. of the total number of visitors make use of the office for historical purposes, and the variety of subjects researched show that good work is being done. Many students since 1912 have made constant use of the documents for examination purposes, and several professors of the various Universities are carrying out particular investigations. The late Dr. Theal has, in the last years of his life, continued his researches amongst the Cape Records, and for the whole of this year Professor George Cory, of Grahamstown, has had the opportunity of working daily in the Archives to gather material for his "Rise of South Africa."

But there is another means of aiding us in our historical research: the systematic printing and publishing of portions of our records. This enables the genuine and enthusiastic student, who is unable to come to Cape Town to read for himself the actual text, and thus he will be able to draw his information from first-hand evidence. Theal's "Records of Cape Colony" and his "Belangryke Historische Dokumenten" are the class of work I refer to. They are invaluable to the student, but this is a class of work which entails a great deal of expenditure, and should be undertaken by the Government of a country. Happily for the South African historical student of the present and future, there now exists an Archives Commission appointed by the Government about a year ago for the Cape Archives. The various branches of historical learning are well represented in its personnel. This body will issue, from time to time, a series of documents containing the actual text of the more important portions of the early records. There is still another medium by which the text of the Archives can be made available, and that is by their publication by a Society. In this respect we are again fortunate, for, at about the same time as the Cape Archives Commission came into being, "The Van Riebeeck Society" for the publication of South African Historical Documents was constituted. The object of this Society is to print, or re-print, rare and valuable books, pamphlets and documents relating to the history of South Africa. Its headquarters are in Cape Town, and its first publication contains two important reports in the Archives dealing with Cape affairs in the years 1717 and 1743. Such a Society deserves the warmest support not only of the historical student, but of the reading public as well. The various Societies in Great Britain, on the Continent, and in America, which undertake the publication of historical documents to elucidate their country's history are well known. The "Commissie Van Advies voor's Ryks Geschiedkundige Publicatie" in Holland has produced many very interesting and valuable volumes. In the United States of America there is a "Department of Historical Research of the Carnegie Institution of Washington." The main purpose of this Department is to provide the present and future writers of monographs and general histories with information on periods or on special sub-

jects not sufficiently covered by other agencies. This assistance may be of two main classes. That is, either with books which guide the enquirer to the location or assist him in the use of bodies of historical sources, or books which themselves present in proper scientific form the full text of important historical materials. The publications of this Department fall into two classes—the one that of reports, aids and guides; the other that of textual publications of documents. The activities of the American Historical Association are too well known to those who take an interest in the development of historical research in other countries to require further comment.

There yet remains another means to aid us in our historical enquiries, the investigation of the Archives of European countries, the State Archives at the Hague, the Public Record Office in London, the National Archives in Paris and in Lisbon, the Vatican Library in Rome, and the Imperial Library in Berlin. All these sources will bear investigation to help us throw light on our own history. The late Dr. Theal during his lifetime made exhaustive searches in some of these. But a systematic search by several investigators will no doubt bring to light much new history. Many countries have sent out historical investigators for the purpose of collecting manuscript materials relating to their history in the Archives of Foreign Lands, for instance, Holland, United States, and Canada. I would like to mention, in passing, the great want felt of some historical journal or magazine, to which the result of an investigator's work could be contributed from time to time. This would also be of great assistance to those whose duty it is to teach history. It would be a means of forming a bond of sympathy between teacher and investigator, and it would organise the efforts of those who are assiduously working in the interest of the study of history. The English Historical Association and its journal *History* must be of the utmost importance to the serious English Historical Student. Could not a similar journal be published here? To my mind it is a matter worth consideration. Speaking from personal experience and that of those who have made use of our Archives, there is no medium by which the results of one's findings could be made known in the form of an essay or short monograph.

In conclusion, may I plead for a deeper and more systematic research into the early History of South Africa. The spade of the investigator has already turned over the first layer of material in the large field of documentary evidence which lies hidden in our Archives. The early diggers have proved to us the mass of wealth which we possess. There still remains a great deal of delving to be done, as well as the work of sifting and analysing the raw material to supply the historical student with the pure and unadulterated substance which will enable him to understand and write our history in its many phases. That the material is there has been shown above; that there have been

and are investigators has also been indicated. But, more researchers, more and more again, are wanted to aid in this work. In the Cape Peninsula is preserved the treasury field of historical documents, and there also are many of the historical monuments and buildings which speak of the ages gone by and are so closely connected with our early history. The material and opportunity are waiting for the researcher. No time should be lost by those interested in this particular branch of study. When the workers have got on with the task we shall look forward to the day when our history will be world known, and we shall have a history written of which we will all be justly proud.

SOME PARASITIC PROTOZOA FOUND IN SOUTH AFRICA—II.

BY

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(*Abstract.*)

Read July 10, 1919.

In continuation of the results of my investigation of the Protozoa found in South African animals (S.A. JOURNAL OF SCIENCE, Vol. XV. (1918), pp. 337-338), I wish to record the occurrence of the following organisms, the accounts given being preliminary ones. The Protozoa found may be grouped according to their systematic position.

SARCODINA.—A species of *Pelomyxa,* apparently *P. palustris,* has been observed once in the freshly-shed fæces of a horse in Johannesburg, and much larger specimens in the drainage from the said horse's stables. *Pelomyxa* usually is regarded as non-parasitic; Minchin calls it sapropelic. An attempt at habituation to "passenger" or partly parasitic life in the intestine of the horse seems to have occurred here. The organism was very slow moving, usually by means of a single pseudopodium, though more than one may be present. The multinucleate body contained food particles in small vacuoles, and was highly granular. Refringent bodies were present. The nuclei were large, each showing a dense karyosome, which practically filled the nucleus.

RHIZOMASTIGINA.—This group is intermediate between the Sarcodina and the Flagellata. A member of this transitional group, or allied thereto, has been observed in a human vomit, and has also been found in soil in Johannesburg. The long, single flagellum is very active, and lashes freely for about two-thirds of its length, the part near the body being relatively stiff. Three phases have been observed: (1) Active, mastigine forms,

each with an amœboid body, one large flagellum, one pseudopodium relatively fixed in position from which the flagellum arises, and sometimes several other small pseudopodia; (2) amœboid forms, which are relatively few, produced by the withdrawal of the flagellum and its subsequent absorption; and (3) cysts, which were not frequent, but could be produced from either of the other forms, by expulsion of all food material and becoming round in shape. The dimensions of the amœboid body of the flagellate form are from 38μ to 60μ in diameter, on measuring four specimens. The free part of the flagellum may be 150μ long. The dimensions of two amœboid non-flagellate forms varied from 30μ to 56.6μ in diameter. Cysts were 30μ in diameter. The organism is allied to the genus *Mastigamoeba* F. E. Schulze, but the flagellum does not arise from the nucleus. A new genus and species may be created for the organism, namely, *Mastigamoebula africana,* with the characters described.

MASTIGOPHORA.—The following flagellata have been found: *Crithidia gerridis* is parasitic in the alimentary tract of *Gerris fossarum,* adults and nymphs from Heidelberg, Transvaal, having been found infected by Dr. Porter and myself. Both flagellate and non-flagellate forms occurred, and the organisms were very frail in appearance. Multiplication is by longitudinal division. A *Crithidia* has also been seen by us in the alimentary tract of *Pycnosoma marginale* from Onderstepoort and Johannesburg. The flagellate stage usually possesses a blepharoplast lying parallel to the long axis of the body. This organism needs further study before details can be given. *Crithidia melophagia* was found in the alimentary tract of sheep-keds, *Melophagus ovinus,* in the Pretoria district. I have pleasure in thanking Mr. H. H. Curson for a preparation of the parasite.

A new Giardia, for which I provisionally propose the name *Giardia denticis,* has been found on rare occasions in the blood of the silverfish, *Dentex argyrozona,* and also in its gut. The flagellate forms are from 5.3μ to 16μ long, and from 5.3μ to 8μ broad. The silverfish were obtained from Kalk Bay. *Giardia intestinalis* has been observed by me from the intestines of man, white rats, rabbits and guinea-pigs in Johannesburg. According to some authors, the forms observed in the rodents, as well as those from man, may each be considered a different species.

Several *Dentex argyrozona* from Kalk Bay have been found to be parasitised in their blood by a *Herpetomonas.* Flagellate and leishmaniform stages occurred. The flagellate body measures about 5μ to 24μ long and 1.5μ to 2.5μ broad. Typical leishmaniform parasites measure 2.5μ to 4.5μ by 1.5μ to 2.5μ, and intermediate forms can be seen. Dividing forms have also been observed. The parasites are not numerous. The organism may be provisionally named *Herpetomonas denticis.* This natural occurrence of a Herpetomonas in fish has an important bearing on the origin of Leishmania in vertebrates, as has been demonstrated in other cases by Fantham and Porter, "Journal of Parasitology," Vol. 2, pp. 149-166 (1916).

Trypanosomes have been found in the blood of several kinds of fish and birds. The fish were chiefly obtained from Kalk Bay, and the birds from various parts of the Transvaal. The blood of the bamboo fish, *Box salpa,* contains a small trypanosome, the body being about 29μ long and 2μ broad. It has a large nucleus near the flagellar end, a small, fairly tightly contracted membrane and a small free flagellum. Another small trypanosome occurs in the blood of *Dentex argyrozona.* It has a pointed non-flagellar end, and a small free flagellum. A distinct basal granule can be seen, situated halfway between the blepharoplast and the commencement of the flagellar border of the undulating membrane. The body of the trypanosome is about 20.6μ long, with a free flagellum of 2μ, while the breadth of the body is about 1.3μ. A narrow trypanosome with a well-marked undulating membrane is present in the blood of a barbel, *Clarias garicpinus,* from Mooi River, Natal. It may be *T. barbi,* Brumpt, 1906. Some specimens had a body length of 32.6μ with a breadth of 1.3μ, the free flagellum measuring 2μ.

Two trypanosomes have been observed in the blood and internal organs of the dikkop, *Gobius nudiceps.* One is larger and more abundant than the other. They also differ morphologically. The larger trypanosome, for which I propose the provisional name *Trypanosoma nudigobii,* may measure from 60μ to 85μ long, the breadth varying from 6.6μ to 7.5μ. The body tapers markedly at both ends, and the endoplasm is very granular. The membrane is usually contracted close to the body. The free flagellum is short. Well-marked myonemes are present on the body, and are usually ten in number. The nucleus is oval, pale-staining, extending across the short diameter of the body. The blepharoplast is small, rounded, and is often enclosed in a clear area. The smaller trypanosome, provisionally named *T. capigobii,* has a narrow body with very pointed extremities. It measures from 42μ to 60μ long, and from 2μ to 4.4μ broad. Five myonemes are usually present on the body. The nucleus is centrally situated, and its long axis is parallel to the long axis of the body of the trypanosome. The blepharoplast is round and distinct, and the membrane arises near a basal granule.

The red-headed weaver finch, *Amadina erythrocephala,* is parasitised by a trypanosome, having a body about 34.9μ long and 6.4μ broad, with a close membrane, and a free flagellum about 3.3μ long. A "crithidial" form of this trypanosome has been seen, which probably represents a stage in retrogression of the flagellum and concentration of the body substance during the early stages of the formation of the resting or leishmaniform stage.

The blue-breasted waxbill, variously named *Uræginthus* or *Estrilda* (*Estrelda*) *angolensis,* harbours a trypanosome possessing a narrow body with a pointed non-flagellar end. The undulating membrane is well marked, shows large waves, and has dis-

tinct myonemes. The body measures about 34μ long and 2.6μ broad, and the free flagellum is about 2.6μ long.

SPOROZOA.—Representatives of this group have been observed by me in a number of vertebrates.

A. COCCIDIIDEA.—*Eimeria stiedae* has been found in a number of rabbits in South Africa, and unless treatment, such as by my catechu method, were provided, the infected animals often died. It is probable that there are several strains of *E. stiedæ* in South African rabbits, the strains varying somewhat in virulence, and the organisms differing only slightly in size.

An *Eimeria* has also been observed in the stomach and intestine of an albacore, *Seriola lalandii*, from Kalk Bay. Gametocytes and oöcysts were seen, and its life-cycle is under investigation. Oöcysts, as found in fæces, measured 33μ to 40μ by 15μ to 20μ, and each contained four sporocysts. Two sporozoites developed in each sporocyst on keeping.

B. HÆMOSPORIDIA.—These include hæmogregarines, leucocytogregarines and halteridia.

Hæmogregarines have been found in the blood and organ smears of various fish from Kalk Bay, lizards from the Cape Peninsula, and birds from the Transvaal. Among fish, hæmogregarines were found in the blood of the panga, *Pagrus laniarius;* the harder, *Mugil capito;* and the Hottentot fish, *Cantharus blochii*. The parasite of the panga, *Pagrus laniarius*, was vermicular, occupied a large portion of the host erythrocyte and nearly surrounded its nucleus. A schizont with a dozen nuclei was also seen. One harder, *Mugil capito*, contained a small, somewhat globular hæmogregarine, and a rounded schizont containing six nuclei, three of which were in process of a second division into two, was observed. The blood of the Hottentot fish, *Cantharus blochii*, also contained a hæmogregarine. It was present as a broad, sausage-shaped, free vermicule, with a broad band-like nucleus extending across the breadth of the body. The vermicule measured 10.6μ long and 4.0μ broad. Multiplicative forms, so far, have not been observed.

Hæmogregarines were found in the blood and organs of several specimens of the small lizard, *Mabuia varia*. In some cases, fairly heavy infections were found. In the blood, the infected erythrocytes showed enlargement and nuclear displacement. Small intracellular vermicules were 9.3μ long and 3μ broad; large ones were up to 20μ long and 5μ broad. A cytocyst was sometimes found around intracellular forms. Free vermicules, measuring from 13.3μ to 23μ long, and from 2.6μ to 6μ broad, were found in the blood. Schizogony into two was found in a few cases in smears of heart blood, and schizogony into two and four merozoites occurred in the liver, spleen and kidney of the host. More than four merozoites have not been observed at present.

A hæmogregarine has been found in the blood of the red-headed weaver finch, *Amadina erythrocephala*. It was present in

the form of crescentic, free vermicules, measuring 8μ long by 2.6μ broad.

Leucocytogregarines from the dog, rat and rabbit in South Africa have been recorded by Porter (S.A. JOURNAL OF SCIENCE, vol. xv. (1918), pp. 335-336). I have also seen these parasites, and now record in addition three leucocytogregarines from fishes.

The leucocytes of the steenje, *Cantharus emarginatus*, harbour a leucocytogregarine that displaces the nucleus of the host cell to one side. The parasites are vermicular, at first with a narrow, crescentic body, measuring up to 10μ long by 1μ broad, which later becomes oval, and may eventually become spherical. The nucleus is usually compact and oval, but in the spherical form, which appears to be the young schizont, the nucleus extends as a band across the body, and shows signs of commencing division in the concentration of the chromatin at either end of the band.

A few examples of an interesting leucocytogregarine have been observed in the blood of *Dentex argyrozona*. The nucleus of the leucocyte was displaced by the oval trophozoite, which had an elongate, curved nucleus and granular endoplasm. The parasites average 10μ long by 4.6μ broad. Free vermicules were also seen.

The white stumpnose, *Chrysophrys globiceps*, also harbours a leucocytogregarine, of which free vermicules, measuring about 8μ long by 1 6μ broad, and young intracellular forms have been observed.

Hæmoproteus (*Halteridium*) *columbæ* has been observed in the red corpuscles of the common pigeon obtained in the districts of Johannesburg and Pretoria. The trophozoites were of the usual form and contained pigment. Both macrogametocytes and microgametocytes were present, the microgametocytes staining much more palely than the macrogametocytes. Multiplicative cysts have been seen in the lungs of the pigeon. The parasites are transmitted by the fly, *Lynchia maura*.

C. MYXOSPORIDIA.—As I reported last year, a *Myxidium* occurs in the bile of various fishes such as the bull klip fish, *Clinus taurus*, and the silver fish, *Dentex argyrozona*. I have seen these parasites again and am continuing their study, both in these and in new hosts obtained from St. James and Kalk Bay. Both trophozoites and spores have been observed. The species has a spore twisted like *Myxidium incurvatum*, but longer than Thélohan's (1892) measurements, being 16μ to 20μ long, which sizes approximate more to those of *M. lieberkühnii*. I have also found this species of *Myxidium* in the bile of a Hottentot fish, *Cantharus blochii*, and in the klip fish, *Clinus cottoides*. Sometimes the *Myxidium* is seen in blood smears—possibly it has got there post-mortem, or as a contamination due to dissection, but it is also possible that the organism may be carried by the blood stream.

A species of *Hoferellus*, that I believe is new to science, has

been found in preparations of the kidney of a *Dentex argyrozona* from False Bay.

Another specimen of *Dentex argyrozona* and one of *Dentex rupestris* from the same area contained examples of the genus *Lentospora* in their blood and on their gills.

A species of *Leptotheca* has been found by me in the bile of *Clinus superciliosus, Clinus taurus, Clinus cottoides* and *Dentex argyrozona* from False Bay. Both trophozoites and spores have been observed, the spores resembling those of *Leptotheca agilis,* but some were larger, being 6μ long and 18μ broad. The infected bile was slightly turbid and varied from yellowish-green to yellow in colour.

A possible Microsporidian has been briefly described by Gilchrist ("Nature," Oct. 3, 1918, pp. 99-100) from the muscles of snoek, *Thyrsites atun,* off the Cape coast, in so-called soft or "pappy" specimens. I have seen preparations of the parasite, and there is evidence of a cyst wall or sporocyst around the groups of four "spore-like bodies" mentioned by the author. The parasites are distributed in the muscles of the snoek, and an examination of "pappy" snoek for Myxosporidia was suggested to him by my remarks on page 239 of the work, "Some Minute Animal Parasites," by Fantham and Porter (1914) regarding a *Chloromyxum* in "milky Barracoutta" in Australia. The snoek and the Barracoutta are either the same or closely allied fish. I consider that the parasite in the snoek is not a Microsporidian but a species of *Chloromyxum,* such as *C. quadratum.* (Since writing this paper, I understand that further fresh material has been examined by Dr. Gilchrist, and will be described by him.)

Ciliata.—In 1918 I recorded the presence of a species of *Trichodina* on the gills of klip fish, *Clinus taurus* and *C. superciliosus* and the bamboo fish, *Box salpa.* New hosts for this *Trichodina* are *Clinus capensis, C. cottoides* and *Pristopoma bennettii,* obtained near St. James.

Balantidium coli has been found by me in the cæcum and colon of three pigs in the Pretoria district. The active ciliate forms were fairly numerous, and caused small ulcers in the cæcum and less frequently in the colon. Some evidence of multiplication by transverse division was observed. Resistant cysts of the organism were present. These, when voided with the fæces of the pig, serve as a means of transference of the parasite to another pig or to man, in whom balantidian dysentery may be produced. *Balantidium coli* is usually stated to be non-pathogenic to pigs, but my observations show that it can be pathogenic even in the pig, especially when the host is in poor condition, as in the cases examined.

Balantidium entozoön has been found in the rectum of the Amphibian, *Xenopus lævis* in the Transvaal. *Nyctotherus cordiformis* also occurs in the rectum of both the adult and the tadpole of *Xenopus lævis* obtained near Johannesburg.

Blepharocorys uncinata has been observed in the cæcum of a horse, and *Isotricha* was present in the rumen and reticulum of a bull, both from the Pretoria district.

SPIROCHÆTÆ.—Spirochætes have been found in three piscine hosts, namely, *Rhinobatus columnæ* (= *R. annulatus*), a sandshark; *Pagellus mormyrus*, the zee basje; and *Dentex argyrozona*, the silver fish, all from False Bay. Heavy infections were not encountered.

The spirochæte from the blood of *Rhinobatus columnæ*, as I reported last year, is small and has somewhat acuminate ends. It shows a diffuse nucleus of chromatin granules. A trace of a membrane or crest was seen in a few specimens. The organism measures from 11.3μ to 24.6μ long by 0.6μ to 1.3μ broad. The short forms are approximately half the length of the long forms, probably due to transverse division of the organism.

The zee basje, *Pagellus mormyrus*, was found to contain a spirochæte in its stomach. This spirochæte varies in length from 12μ to 28.6μ, and has a breadth of 1μ. It has a diffuse nucleus of chromatin granules, and some show a tightly contracted membrane or crest.

Examination of scrapings of the gills of the silverfish, *Dentex argyrozona*, showed the presence of a spirochæte. The dimensions of the organism are from 16μ to 34.6μ long, with a breadth of 1μ. Multiplication by fission was observed in life.

DIFFRACTION-PHENOMENA IN FILMS OF BLOOD CELLS AND IN SURFACE-CULTURES OF MICRO-ORGANISMS.

By A. PIJPER, M.D., L.S.A.

(*Abstract.*)

Read July 11, 1919.

The author, with the aid of lantern slides, gave a brief synopsis of the physical principles of diffraction and interference, and explained how films of red blood cells and of more or less spherical micro-organisms could be regarded as "diffraction-gratings." An apparatus was demonstrated by means of which a powerful beam of parallel light-rays could be projected on such "natural diffraction-gratings," and the resulting diffraction-phenomena were made visible on the receiving screen of the apparatus.

It was seen that suitable films of this nature gave rise to diffraction-phenomena, consisting of circular spectra, measuring from about 5 to about 30 centimetres.

The relation between the diameters of these spectral rings and the diameters of the bodies composing the "grating" was discussed, and evidence was brought forward to uphold the theory that the diameter of the spectral rings was a function of the diameter of the bodies constituting the "grating." It was pointed out that this circumstance provided the observer with *a new method of measuring the diameter of "round" bodies of microscopical size,* and stress was laid on the fact that this new method is superior to the old method of taking microscopical measurements for the following reasons:—

(1) The dimensions actually to be measured (diameter of spectral rings) surpass those to be calculated (diameter of bodies in grating) so many times, that the method becomes *sufficiently sensitive to register differences in size which have to be expressed in hundredth parts of a micron.*

(2) As all the bodies which are struck by the beam of light contribute towards the formation of the diffraction-phenomenon, the method *gives the average diameter of millions of bodies by means of one measurement and one calculation only.*

A graph was shown which illustrated that the apparatus had made it possible to record changes in diameter occurring in red blood cells under the influence of very slight changes in osmotic pressure of the fluid surrounding them, and by the addition of minute quantities of specific hæmolytic *amboceptor.*

A striking difference in diameter of the spectral rings, as produced by means of blood cells of human beings and those of sheep, was readily made visible by the apparatus.

In conclusion, a series of surface-cultures of micro-örganisms, all of different sizes, were placed on the stage of the apparatus, and a marked difference in diameter of the spectral rings produced by them could be observed in every instance.

For further particulars as regards the apparatus, its applications and all details of the method, the reader is referred to *The South African Medical Journal* for August, 1918, and June, 1919.

THE FRUIT SHED IN RELATION TO THE CONTROL OF THE CODLING MOTH.

By F. W. Pettey, B.A., Ph.D.

With 1 *Chart.*

Read July 10, 1919.

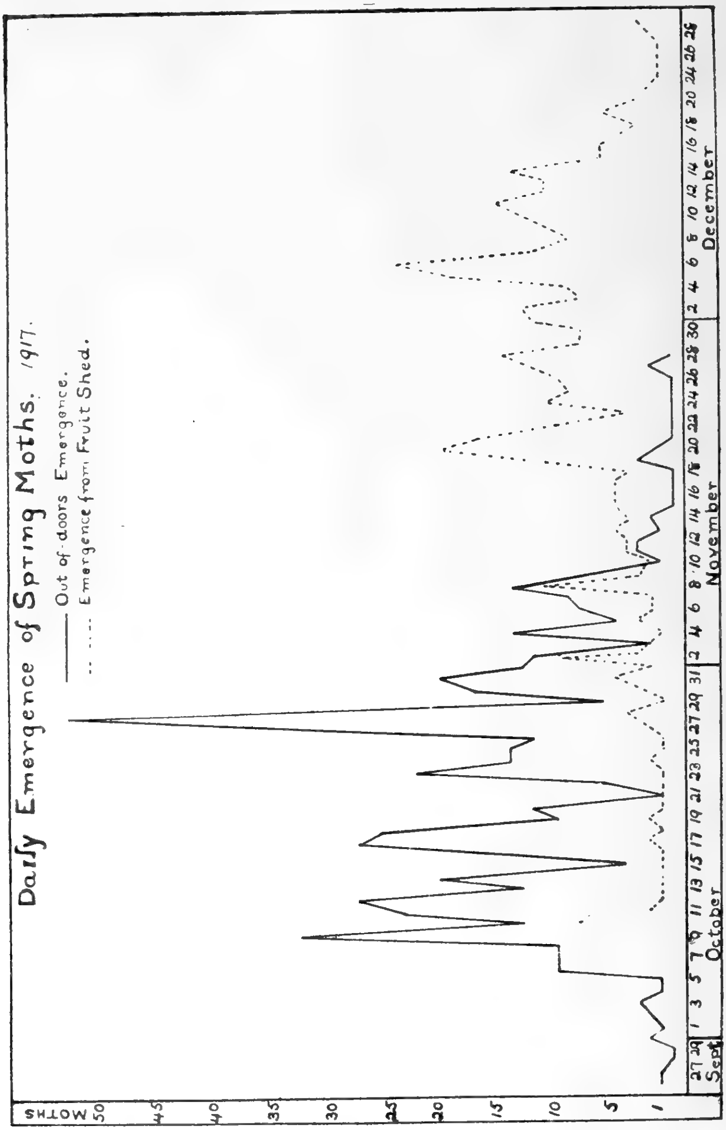
Little has been written regarding the control of the codling moth in the orchard as affected by its emergence and control in fruit sheds. Chapin, in the "Report of the Second Annual Convention of California Fruit Growers," in 1883, states that over 15,000 moths were caught in a fruit room in one season. Sampson, in Bull. No. 41, U.S. Department of Agriculture, 1903, states that a Mr. de Long, in California, reported the capture of 11,974 moths in his fruit shed from April 15 to August 12.

Burgess, in a paper read at the meeting of the American Association for the Advancement of Science, held at Philadelphia in 1914, reports that cyanide 1-1-3 formula for 100 cubic feet of room space killed only about 40 per cent. of the larvæ. L. Cæsar, of Ontario Agricultural College, suggests, in a paper concerning codling moth written in 1911, that fumigation with sulphur is probably the best remedy for codling moth control in the fruit shed, but apparently his statement is not based on experimental data. Various writers have reported greater infestation of the insect in that part of the orchard nearest the fruit shed, and have recommended the screening of doors and windows to prevent the flying of moths to the orchard which emerge in the fruit shed.

It is quite evident that the custom among fruit growers to bring pears and apples to sheds and store them a more or less considerable length of time, until they are ready for cutting, before drying, or until they are packed for market, makes it possible for the majority of the larvæ that are in the infested fruit to leave the pears and apples, and seek shelter in cracks and crevices of the walls, floors and boxes of the packing shed, where they make their cocoons, hibernate, and finally develop into moths, which emerge in the packing sheds in the spring.

The failure of Burgess to destroy these hibernating larvæ satisfactorily was probably due to the fact that the cyanide could not penetrate many of the cocoons or crevices where the larvæ had sought shelter. It is quite probable that sulphur fumes would be no more satisfactory than cyanide in this respect. Success with fumigation measures is at a disadvantage, as it must be attempted during the cold temperature of winter or very early spring, before the insect pupates, a time when gases will not penetrate small openings, and when the respiration of the hibernating insect is very slight. Many fruit sheds are so constructed

and so located that these moths may fly in considerable numbers from the buildings to the orchard. Packing sheds in South Africa are generally made of corrugated iron, or of bricks and



cement with a thatched roof. Practically no attention is given to keeping the sheds closed during the emergence of Spring moths, and the majority are so built that keeping them entirely closed is impossible, or they are so large that it would not be

practical to fumigate them, even if fumigation were a successful method of control.

To determine how closely the emergence of Spring moths in a fruit shed with thatched roof and brick walls compared with the emergence of Spring moths under out-of-doors conditions, observations were made at Elsenburg during 1917. The shed was kept closed as much as possible, but on several occasions it was found to have been left open by native labourers during the day. The records, which are illustrated in the chart on p. 194, show that the, approximately, 200 moths emerging in the fruit shed appeared about six weeks later than 568 moths emerging under normal out-of-doors climatic conditions. Consequently, had the packing shed moths flown to the orchard, the larvæ hatching from the eggs laid by them would have been difficult to control, firstly, because the spray applications would not have been timed to destroy them, and, secondly, because the later eggs hatch the greater will be the percentage of larvæ which attempt to enter the sides of the fruit, where they are poisoned with less success than in the calyx cup. Such a condition might easily result if a fruit shed were to be kept closed a part of the time and opened occasionally during the period of moth emergence.

In view of the unsuccessful results of destruction bv fumigation of hibernating larvæ in fruit sheds, the frequent impracticability of screening of the packing house, or the prevention of the escape of the moths, and the possibility of the emergence in fruit sheds of the Spring moths—under certain conditions, not coinciding with their appearance in the orchard under natural out-of-doors conditions, when fruit sheds are not so constructed that they can be kept closed to the exit of moths from September to the end of the fruit season—they should be kept as open as possible, day and night, in order that the moths may emerge at the same time as under normal conditions, and in order that the spray applications may be timed to control their progeny as well as the progeny of those moths emerging in the orchard. It should be emphasised, however, that fruit sheds should be so constructed that they can be effectively closed to the exit of moths.

The sorting and temporary deposition of the infested fruit of the packing house in shallow, open pens so constructed that there are no cracks in the floor or sides, and surrounded by strips of hessian or loose boards full of crevices so arranged as to attract the larvæ leaving the infested fruit to these traps for shelter, where the cocoons may be periodically collected and destroyed during the fruit season, might be of advantage in fruit sheds which cannot be closed to the exit of moths. During the winter months all cracks and corners in such open houses should be examined thoroughly and all cocoons found should be crushed or destroyed.

THE WATER SUPPLY OF KINGWILLIAMSTOWN.

By T. George Caink, M.Inst.M.&Cy.E.

With Plates XI, XII.

Read July 7, 1919.

It has been suggested that, in view of the visit of the Association to the Perie Dam, a short paper describing that portion of the waterworks of Kingwilliamstown would be of interest.

Historical.

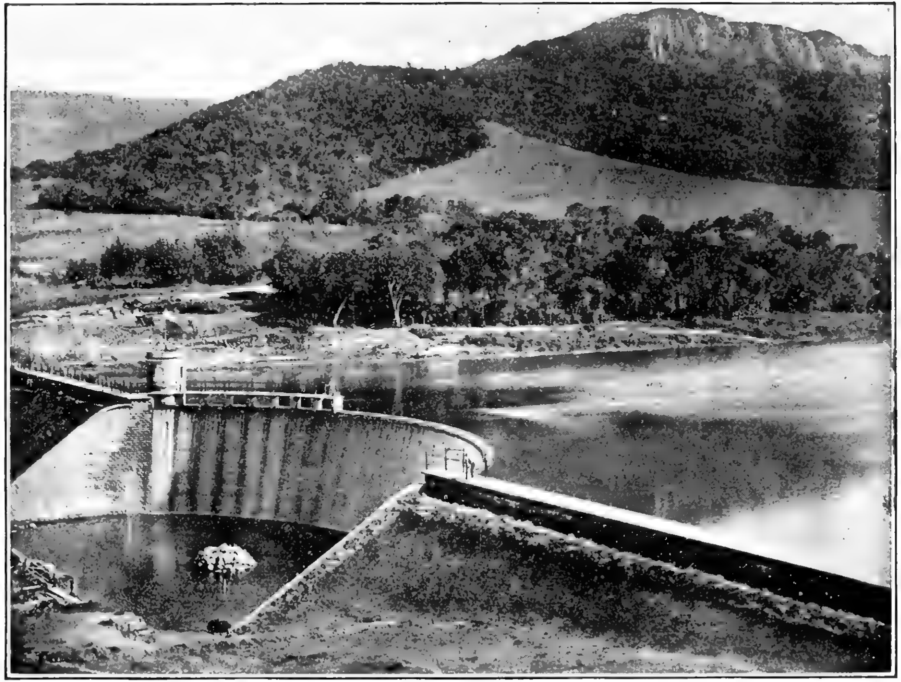
The Buffalo River being the natural source of water for Kingwilliamstown, the history of its water supply has been the story of a succession of dams built across the river, one above the other, as the town grew. The first of these was constructed by the pioneer missionary, the Rev. John Brownlee, the founder of Kingwilliamstown, who cut a furrow about two miles in length to supply his mission station with water. When the mission station became a military settlement, the furrow was taken over by the military authorities, who also built a masonry dam across the river. Subsequently, the furrow and dam were taken over by the municipal authorities, who also built a number of masonry dams across the river, one above the other, to supply the town with water, as the growth of the town required a higher and higher source of supply. Previous to the year 1908, at least five dams had been so constructed across the river one above the other, the highest of which was situated at a place called Izeli, at an elevation of about 260 feet above the town and seven miles distant. This dam, known as the Intake Dam, only held about two million gallons, so that the town had very little reserve to depend upon. The Maden Dam at the Perie, which the Association is to visit, is built at an elevation of 550 feet above the town, and holds 80 million gallons. It is situated in beautiful surroundings, just within the Perie Forest, above the inhabited zone. The distance from Kingwilliamstown is about 14 miles.

Catchment Area.

The catchment area above the dam is about 9,300 acres, and consists of forest-clad mountains rising to a height of between 3,000 and 4,000 feet above the dam, with a few grassy glades, particularly near the summit of the mountains.

Run-off.

The run-off from the catchment area is dealt with in the author's paper on "The Possibilities and Development of the Coastal Belt of South Africa."



The Dam at the Perie Forest. (Water-supply of Kingwilliamstown.)

T. GEORGE CAINK.—THE WATER-SUPPLY OF KINGWILLIAMSTOWN.

The Dam.

The dam was built some nine years ago. It is somewhat unusual in plan, consisting of a central portion, which is curvilinear, and a straight portion on either side, which is the ordinary gravity section. These also act as abutments for the curved portion, the sloping walls on either side of the cushion acting as buttresses. The ends of these are joined by a low concrete wall, into which the measuring weirs are built; this originally formed a water cushion four feet deep for the overflow of the dam, but, as will be referred to later, has since been raised. The objects sought to be obtained by this mode of construction were: First, economy, as it enabled the section of the dam to be reduced at the point where it was the greatest height, the thickness of the curved portion at the base being only 12 feet, as compared with 27 feet, which would have been required for the ordinary gravity section. Secondly, it would allow for a certain amount of expansion and contraction to take place in the dam through changes of temperature, instead of setting up unknown stresses in the dam itself, which must be produced more or less in long, straight dams built in between solid rocks, in a country where there are such extreme variations of temperature. The central curved portion of the dam is used for the overflow, the actual spillway being 220 feet in length and 3 feet deep. This form of construction has proved quite satisfactory, there being no signs of cracks visible in any part of the structure. The upstream face of the dam was built of plain concrete blocks, and the downstream side of rock-faced blocks. These rock-faced blocks have not proved satisfactory, for although they looked very pretty at first in breaking up the water flowing over the dam, the rock face was rapidly worn off by the action of the water. It would, no doubt, have been better if both upstream and downstream faces had been built with smooth concrete blocks.

The curved portion of the dam was further strengthened by a double row of old railway metals, the railway metals on the upstream side being continued to the top of the dam; those on the downstream side were only carried up to a height of about 15 feet from the foundation. To those vertical railway metals were bolted horizontal rails throughout the whole length of the curved portion of the dam, and were continued well into the straight portion. Both vertical and horizontal rails were 10 feet apart. These old railway metals were not intended to form reinforced concrete, in the ordinary sense of the word, but to thoroughly tie the work together horizontally and vertically; also to form a good tie between the curved portion and the straight portion forming the abutments. They were also let some distance into the solid rock below the foundations of the dam, so as to form an additional safeguard against any tendency to slide. These rails were fixed into position before the construction of

the dam, and greatly facilitated the work of building, as it enabled a tramway to be constructed throughout the whole length of the work for the conveyance of concrete and "plums," or displacers, which could be tipped from the railway direct into the work. As the height of the dam rose, so the tramway was lifted higher and higher up the railway metals.

Last year it was discovered that considerable erosion had taken place on the downstream surface of the rocks. The holes formed by this erosion have been filled in with concrete and the cushion wall raised about 3 feet, so as to increase the depth of the water in the cushion. The manner in which this erosion took place was rather interesting. The first year the overflow from the dam formed a hollow all round, about 15 inches deep; during the next five years it increased to two feet; during the following year it went from 2 feet to 6 feet. The explanation was that there was a hard layer of shale about 2 feet thick, underlain by a much softer layer 4 feet thick, so that the moment the hard layer was worn through, the softer layer eroded very rapidly; it also eroded in a horizontal direction to a width of 4 or 5 feet underneath the hard layer, necessitating the work above referred to.

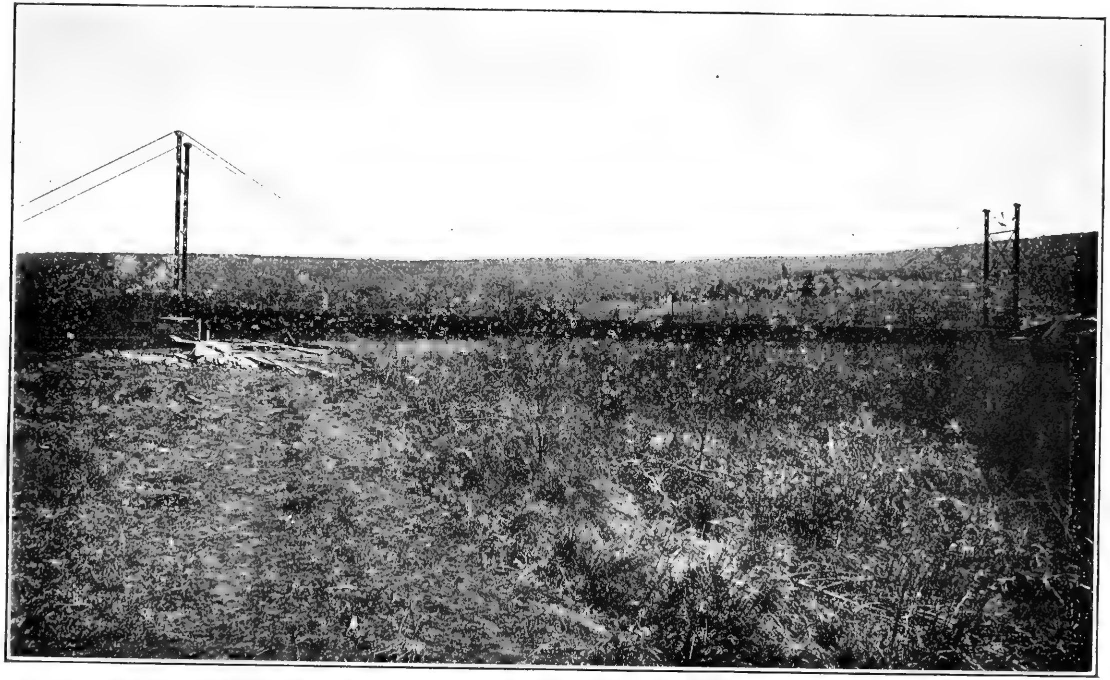
The reservoir is stocked annually by the Council with trout, which seem to thrive well, and some good fish have been taken, both rainbow and brown varieties.

Pipe Line.

The pipe line has a total length of 13 miles. The first 6½ miles consist of 10-inch diameter cast-iron pipes with turned and bored joints, laid in 1881 in connection with the old scheme; the remaining 6½ miles, from Izeli to the dam, are of 15-inch diameter inserted joint steel pipes three-sixteenths of an inch thick.

The new pipe line crosses the Buffalo River five times, and, owing to the precipitous banks and great depth of water, in two instances bridges are used to carry over the pipes. Both are of the "cantilever suspension type," the one at Izeli having a clear span of 150 feet, and the one in Haynes' Farm, near the dam, two spans of 45 feet each. In both cases the pipes are carried by iron supporters underneath the bridge decking, and provided with corrugated expansion joints.

The steel pipes have given very little trouble; only two small sections have shown any signs of leakage. One section was near the dam, the length of pipe affected being about 50 yards. This was in made-up ground with a considerable amount of soakage passing through it. The author covered these pipes with concrete, reinforced by means of No. 11 black iron wire; since then there has been no further trouble. The other section which gave trouble was at the bottom of a narrow kloof about four miles below the dam, the length of pipe line affected here



Bridge carrying water-main across Buffalo River.

T. George Cainy.—The Water-supply of Kingwilliamstown.

being also about 50 yards; so far, all that has been necessary has been to put four clips on the pipe; but should it get worse, it is the intention of the author to deal with it in the same way as the section near the dam, namely, by covering it with reinforced concrete. This short section of pipe line is in particularly bad ground, as the kloof is crossed higher up by a dolorite dyke, and where the pipe line crosses there is a deposit of black soil formed from the weathering dolorite, together with a good deal of lime, forming white nodules and incrustations, in and on the surface of the soil. The remainder of the pipe line has given no trouble whatsoever, and shown very little signs of corrosion.

The accompanying photographs (Plates XI, XII) show the Impounding Dam at the Perie, and the cantilever suspension bridge carrying the 15-inch pipe across the Buffalo River.

SUICIDE FROM A LEGAL AND ETHICAL POINT OF VIEW.

By G. T. Morice, B.A., K.C.

Read July 9, 1919.

Most of the acts treated as serious crimes by law are also strongly condemned by morality. Thus murder, assault, robbery, theft, fraud, are not only crimes in the eye of the law, but are also from an ethical point of view, evil deeds. It is true that this does not altogether apply to political offences, such as treason and sedition, which are regarded as heinous crimes by law, though not involving moral depravity. But those offences, threatening as they do the stability of society, are of such a dangerous character that most persons will agree that they should be treated with severity by the law. In the case of suicide, however, there is a wide gulf between public opinion and law—at least, English law. The two seem to belong, as it were, to different strata of civilisation.

The English law on the subject is clear; the "trumpet gives forth no uncertain sound." Suicide is a *felony*, that is, one of those heinous crimes, including murder, rape, burglary, which found a place in the simple code of our ancestors, and were generally punished by death and confiscation of property. The person who killed himself was a *felo de se*, a felon as regards himself. In the case of the successful suicide the death penalty could not, of course, be carried out. But the outraged law was not to be baulked of its vengeance, and found a vent for it in the treatment of the corpse of the felon. The body was buried at midnight, without Christian rites, on the highway, generally at cross-roads, and with a stake passed through it. There we

have a combination of superstitious practices. The stake was supposed to interfere with the mobility of the ghost. The object of choosing a situation where two roads crossed is not quite clear. But the practice of putting evil things at cross-roads is found in different parts of the globe. It has been suggested that it was supposed to lead to the dispersion of the mischievous influence, as a bad smell in a house is dispersed by throwing open the door and windows.

This mode of burial was altered by statute so late as 1823—that is, in the lifetime of persons now living. The forfeiture of the goods of the suicide was abolished in 1870, though I understand it had become obsolete before that time. Such goods and chattels were forfeited to the Crown on a verdict by a coroner's jury to the effect that the deceased had been guilty of the crime of suicide—that is, had deliberately killed himself. The forfeiture was averted if the jury found that the suicide was committed while in a "state of unsound mind." So that this verdict, which is notoriously given whether or not there is proof of insanity, was formerly of importance to the relatives of the deceased and a check upon the cruelty of the law.

Though those barbarities have been dispensed with, under English law suicide is still a form of murder. Rather illogically, however, an attempt to commit suicide is not an attempt to commit murder. Still, it is a crime punishable by fine and imprisonment. It is further a rule of English law that where two persons agree to commit suicide and one fails in the attempt on his own life, he or she is guilty of the murder of his companion who was successful in getting rid of himself or herself.

It is rather surprising that in South Africa our law on the subject of suicide is more enlightened than that of modern England, though our law is that which prevailed in Holland some 200 years ago. There seems no doubt that according to the law of this country suicide is not a crime, unless possibly when committed to escape punishment for a crime. Van Leeuwen, an authority on Roman-Dutch law, who wrote as early as 1678, humanely observes: "With reference to him who commits suicide and purposely causes his own death, and whether he is to be punished, we must observe that the death of such a person is not punishable unless it duly appears that he has intentionally and wilfully killed himself after having committed some crime out of remorse of conscience and in order to escape punishment. But they who have not committed any crime, but merely destroyed themselves out of grief and despair, are not punishable." Van der Linden, who wrote in 1806, lays down that suicide is not punishable, though he adds that it is not permissible (ongeoorloofd). Judge Kotze, in his notes to Van Leeuwen, suggests that attempted suicide may be a crime at the present day, at least when the attempt is made to evade punishment for a crime. Still, I think that the most probable statement of the

law is that neither suicide nor attempted suicide is a crime in this country.

It is interesting to note that in ancient times it was the custom in Holland, as comparatively recently in England, to confiscate the goods and maltreat the body of the person who committed suicide. But in Holland the corpses were merely drawn on a hurdle and hung on a gallows. There do not seem to have been any special precautions against the ghost of the deceased.

It would be interesting to know whether native custom in South Africa treats suicide as a crime. Suicide is so rare amongst the natives of South Africa that it is possible that custom does not deal with the subject.

Thus far I have considered suicide from a legal point of view. It will generally be agreed that suicide ought not to be treated as a crime in law. The object of the criminal law is to protect individuals from one another, not from themselves. A man may mutilate himself without the law interfering. He may get as drunk as he likes so long as he does not disturb other people. In addition to this, the law has no means of punishing a successful suicide. At the same time, an attempted suicide might be punishable when it is an offence against public decency. We do not want to have persons throwing themselves from public monuments or cutting their throats in the street. And there should be some means of preventing this.

I have now to consider suicide more from the ethical or moral point of view.

There has never been that unanimity with regard to the moral aspect of suicide that there has been with regard to such acts as homicide, robbery, and so forth. In the East, in any case in China and Japan, suicide does not appear to be regarded as a wrong act. In India the practice of "suttee" or widows killing themselves on the death of their husbands was looked upon as meritorious. In Europe, opinion has varied greatly. In the first few centuries of the Christian era there was a great development of pagan morality in Stoicism. The teachings of two great representatives of Stoicism—Epictetus and Marcus Aurelius—are sources of comfort and strength to many in the present day. They present a lofty morality which is not coloured by the other-worldliness of early Christian teachings. The Stoics considered suicide to be justified in certain cases. Epictetus imagines those he is teaching coming to him and asking him whether they may not leave a worthless world of materialistic wants, a world of robbers and courts of justice and tyrants, and his answer is: "Friends, wait for God; when He shall give the signal and release you from this service, then go to Him; but for the present endure to dwell in this place where He has put you; short, indeed, is this time of your dwelling here, and easy to bear for those who are so disposed. For what tyrant, or what thief, or what courts of justice are formidable to those

who have thus considered as things of no value the body and the possessions of the body. Wait, then! Do not depart without a reason." It is to be noted that he puts thieves and courts of justice on the same footing. He regarded both as a means by which persons were deprived of their property. This is rather an extreme view, especially when we consider that Roman law was at its zenith at the time.

But though Stoicism does not condemn suicide in all circumstances, its great maxim was restraint and endurance; it preached manliness and courage in the face of misfortune, and it is quite opposed to the hysterical and emotional type of mind which tends towards suicide.

The idea of the extreme sinfulness of suicide, which we have seen is reflected in the older law, appears to have been a development of Christianity. This is curious when we take into account that the central fact of Christianity is to some extent analogous to suicide, and also that there is nothing in the Old or New Testaments to account for the severe attitude of reprobation adopted by the early and mediæval church. In the Old Testament several suicides are narrated. Saul (I Samuel, ch. xxxi) is described as killing himself after a defeat by the Philistines to prevent his falling into their hands. His armour-bearer, faithful in death, follows his example. In the lament of David on the death of Saul and Jonathan, their deaths are described as of the "mighty fallen in the midst of the battle." In II Samuel, ch. xvii, 23, Ahitophel is described as killing himself because his counsel has been disregarded by Absalom. Zimri, the usurping king of Israel, to avert capture, kills himself by setting the royal palace on fire (I Kings, ch. xvi, 18). In the New Testament Judas Iscariot is described as hanging himself as a refuge from self-reproach and shame. There is no special stigma attached to the act in the New Testament. It was left to a later age to propound the fantastic view that Judas committed a greater sin in hanging himself than in betraying his master.

The early Christian fathers took up a very severe attitude towards suicide. But the arguments that they used show the want of Scriptural authority on the point. St. Augustine and St. Chrysostom treated it as a form of murder. It was argued that the Commandment, "Thou shalt not kill," included killing oneself. I do not think anyone with a knowledge of primitive law would contend for such an interpretation. Besides, why stop there? Why not extend the Commandment to animals and even to plants? St. Thomas Aquinas, the theological philosopher of the Middle Ages, denounced suicide as the worst form of murder, a killing not only of the body, but of the soul—a peculiar view of an act which after all may proceed from altruistic motives.

A very ordinary view of suicide is that expressed by Shake-

speare in Hamlet's soliloquy, "To be or not to be, that is the question—

Whether it were better for the mind to suffer
The slings and arrows of outrageous fortune,
Or to take arms against a sea of troubles,
And by opposing end them," etc.

Suicide is shrunk from because it may have disastrous consequences to the individual in a possible future life. Such fears may serve a useful purpose in preventing rash suicide from selfish motives, such as suggested itself to Hamlet. But I do not think that this is a high-minded view to take of the question.

It seems to me that we ought to ask not whether we may be punished for suicide in another life, but whether it is right or wrong; and that the best test whether it is right or wrong in a particular case is how far it affects our fellow-men. A suicide committed with the object of injuring any of our fellow-men or of shirking our duties to them is of course wrong. But when the act is done with the object of relieving them from a burden or other evil, it appears to me that it may be not only inexcusable, but praiseworthy. Where misery that can serve no good purpose is in prospect, as when melancholia threatens, it certainly seems excusable. But apart from purely moral considerations, it is surely the rashest of all rash acts without sufficient reason to put an end to a life which one has only a single chance of living in all eternity.

But I do not wish to press my own opinion on the subject. I wish chiefly to lay before you the undoubted change of view on the question, which, I think, ought to be more generally recognised.

THE SYSTEMATIC POSITION OF THE FUNGUS CAUSING ROOT-DISEASE OF SUGAR-CANE IN NATAL AND ZULULAND.

By Paul A. van der Bijl, M.A., D.Sc., F.L.S.

Read July 11, 1919.

Ever since 1917 we have given attention to the root-disease of sugar-cane, and in a pamphlet published in 1918* we mentioned that two Basidiomycetous fungi occur on and around the roots and basal leaves of cane in our plantations, namely, a fungus which shows sphæro-crystals of calcium oxalate in its mycelium, and which we referred to the *Phalloids,* and the second one, which we then provisionally referred to *Marasmius sacchari.* Neither of these two have to date been observed to fruit naturally in our plantations. The latter fungus was isolated, grown in the laboratory, and this short paper deals with it only, and now places it systematically.

Though grown on a number of different media, and under the most varied conditions, every attempt made in the laboratory to induce it to fruit gave only negative results.

In the pamphlet above cited we make mention of certain inoculation experiments, and in these experiments, following the method which gave success with *Marasmius sacchari* in the hands of Howard in the West Indies, we attempted to induce it to fruit under conditions more natural than would obtain in a laboratory, but were once again not successful.

Marasmius sacchari fruited comparatively easily in the experiments recorded by Howard, and our continued non-success led us to doubt whether the fungus in South Africa is the true *Marasmius sacchari* of other cane countries. We decided that it was not, and that our fungus belonged to the genus *Himantia,* a genus of Basidiomycetous fungi the fructifications of which are unknown. Our fungus showed peculiar stellate crystals of calcium oxalate borne on short, swollen (at their apices), lateral outgrowths of the hyphæ. Reviewing the literature of cane-root fungi, we found these crystals had been previously observed, but until towards the end of 1917 it was not quite clear whether or not the fungus bearing them was *Marasmius sacchari.*

Lewton Brain (1905) appears to have been the first to draw attention to the presence of these crystals in a cane-root fungus, and he, too, mentions it as remarkable that at that time no toadstools had been observed in Hawaii. Later Cobb (1909) mentions the existence of two species of *Marasmius* (*sacchari* and *Hawaiiensis*) in Hawaiian cane-fields, and he refers to the

* "Root Disease in Cane and Suggestions for its Control." Bull. No. 4 of 1918, Dept. Agriculture, Union of South Africa.

fungus of Lewton Brain under the name "stellate crystal fungus." Cobb hence considered that the stellate crystal fungus was a distinct and different fungus, in which view, however, Lyon (1909) did not agree, and he mentions that he had observed fructifications of *Marasmius sacchari* connected with the mycelium bearing the above-mentioned stellate crystals, and hence concluded that these two are one and the same fungus, that is, the stellate crystals belong to the *Marasmius sacchari*. Here the matter stood until towards the end of 1917, when Johnston* definitely named the stellate crystal fungus *Himantia stellifera*, and gives the following description of it:—"Mycelium cobwebby, or somewhat dendritic, white, ascending the lower leaf sheaths and penetrating the roots. Hyphæ with clamp connections and bearing on short side branches stellate crystals of calcium oxalate. No fruiting bodies known." This description evidently embraces the fungus previously mentioned by Lewton Brain and Cobb.

The present writer agrees with Cobb and Johnston that the "stellate crystal fungus" is distinct from *Marasmius sacchari*, and he now definitely refers the fungus responsible for root disease in cane in Natal and Zululand to Johnston's *Himantia stellifera*, "the stellate crystal fungus." In doing this he in no way overlooks the presence of other root fungi, such as *Phalloids* before mentioned, but regards the former as more widespread and of greater economic importance.

Of this fungus Cobb, writing from Hawaii, says: "It is the most common, and in all probability the most destructive of the fungi causing root-disease in cane in Hawaii."

J. A. Stevenson, Esq., formerly of Porto Rico, in a personal letter to the present writer, says: "I note you find *Himantia stellifera*, which in Porto Rico is the most common fungus on the roots and base of cane stools. I have been of opinion for some time that it does more harm than *Marasmius* or any of the other fungi present on or about the roots of cane."

In growing the fungus on artificial media we noticed that though the lateral outgrowth, swollen at their apices, developed from the hyphæ, no crystals formed on them. These crystals again developed when the fungus was grown on sterilised sugar-cane stalks or leaves. In the original description of *Marasmius sacchari*, Wakker makes no reference to these crystals, and neither does Howard, who also obtained this fungus in pure culture and induced it to fruit.

We also, in our observations, noted that clamp connections, though present in the hyphæ, occur sparsely, and have to be well searched for. This point was also noted by Lewton Brain for his fungus with stellate crystals.

The present distribution of *Himantia stellifera* is as follows: Hawaii, Porto Rico, Jamaica, Natal, and Zululand. In

* Johnston's views were not known to the present writer when the publication before mentioned was prepared.

addition to cane, it has also been found on a number of grasses, and we, by planting *Imperata arundinacea* (the um-Tente grass) in tubs to the soil of which was added sterilised maize on which the fungus was growing, have shown it capable of subsisting at the base of this grass. Probably it occurs on this and other grasses in South Africa in the wild state also. Whether the true *Marasmius sacchari* occurs in South Africa must remain undecided until toadstools of it are collected.

Natal Herbarium,
Berea, Durban,
June, 1919.

SUTO ASTRONOMY.

By Rev. G. Beyer.

With 1 *Figure.*

Read July 10, 1919.

Although the Basuto, from our point of view, possess a more or less limited knowledge of Astronomy, it is, however, interesting and worth the trouble to inquire how far this knowledge goes, and what ideas primitive people form of the celestial world.

The *sun* is called "le-tjatji," in old Sesuto "le-laka," corresponding to "i-langa" in Zulu.

It is considered as a big, burning disc, which passes over the "le-ratadima" (sky) from "bo-hlabatjatji" ("east") to "bo-sobelatjatji" ("west").

Each day, in their ideas, has its own sun; in the evening the old one, "sobela" ("disappears"), the next morning another sun will "hlaba" ("pierce"), and so on.

The constant observation of the sun has created a wonderful sense of orientation amongst the Basuto. They will never lose sight of "the north" ("le-tzweta") or "the south" ("borwa," *i.e.,* the country where the "Ba-rwa" ("Bushmen") live; they always know where the sun rises and sets. When travelling with them they will never be in uncertainty about the direction.

Last, but not least, the sun is for the Mosuto what a watch is for us. If they want to make an arrangement for a rendezvous at an appointed hour they point to a place in the sky and say: "We shall meet when the sun stands there!" It may be in the morning ("go-sasa" or "bo-sasa," *i.e.,* when "the day is breaking"); at noon ("mo-segare," *i.e.,* when the sun is in "the middle of its orbit"); in the afternoon ("ka me-riti" *i.e.,* when "the shadows grow longer"); or in the evening

("ka ma-ntjebōa," *i.e.*, when it is "getting cool" ("tjididi") "again" ("bōa").

The summer and winter solstices, though not ruling the Suto year, are noted; the points where the sun "turns" ("bōa") in the middle of winter and where in summer are known accurately.

The Basuto distinguish three different seasons of the year:

"se-lemo," the "ploughing-time" or spring;

"le-hlabola," the time when there are plenty of eatables "sweet to the taste," or summer; and

"ma-rega," the time when the plants, etc., "rega," *i.e.*, "get dried up."

The *moon* is called "kgwedi," or "ngwedi."

The apparition of the new moon is always received with cheers by the Basuto, especially by the children. The first who sees it shouts: "kgwedi oē!" "there is the moon!" and soon a many-voiced echo: "kgwedi oē!" is heard.

The day after the new moon has made its appearance it is forbidden to till the fields or to cut trees; it is a day of rest. The moon must be left undisturbed to "tiea," *i.e.*, "to become strong," first.

The appearance of the crescent is also carefully examined by the Basuto. If its horns are turned down towards the earth that is regarded as a good omen: "All sickness has been poured out!"; on the other hand, if the horns are turned towards heaven that is a bad omen: "The moon is full of misfortunes!"

There is a curious ceremony among the Basuto of presenting little children to the moon, which is performed when a child enters its "second month" ("mo-kuruetjo").

As soon as the new moon appears in the sky plenty of "motogo," or "light beer," is prepared. The next evening after sunset, when the moon becomes visible, the big girls of the kraal call all children, boys and girls, together, take the child in question together with the beer and go outside, not far away from the kraal. The girls take hoes with them, the boys small bows and arrows. Then they sit down; one girl takes the child, turns it towards the moon, and points to it, saying: "Bona, mo-nkane wa gago shu!"; that is, "Look there, that is your friend!" The girls then make a little garden for the child, plant, when in summer, some mealies, beans, or monkey-nuts; in the meantime the boys play with their bows and arrows. When the girls have finished tilling and planting their little piece of ground, then all sit down, enjoy their beer, and afterwards go home.

Each "moon" or month is considered as being a new one; the old one having "died" ("e huile"), a new one "sets" ("e dutshe").

When the first quarter appears the moon is said to "file off its horns" ("e ritela dinaka"); when it is full moon: "it has filed off its horns" ("e ritetshe dinaka"), or "e tolokile,"

that is, "it is rounded off"; the last quarter is called: "e dumedisha le-tjatji," that is, "it salutes the sun."

Each moon bears a special name:

January is "Phato" (ma-sohlo), that is, the month in which the first green mealie-cobs ("ma-sohlo") were broken off and eaten.

February is "Legobye" (la mpa le modula), or the month of "the fully developed blossom."

March is "Ma-hlohlokwe," the month of "the thin porridge."

April is called: "Se mphe, ki khotshe!", that is, "do not give me any more, I have had enough!"

May is "Shishishebo," that is, "there is the "se-shebo" or "side-dish." Beans are ripe in this month and eaten as "se-shebo."

June is "Le-folwe," the month in which the corn is "thrashed out" ("go folwa").

July is "Le-folwane," diminutive of "Le-folwe," the preceding month.

August is "Phupu," the month in which the first trees start to "fupuga," or "to blossom."

September is "Phepelelo."

October is called "Morenane," or the "young master." The tilling-time begins.

November is "Moseganong" ("kgwedi ea ngwetji eo bogale"), that is, the "month of the angry daughter-in-law."

December is "Ngetaboshego" ("ki a fofa"), or "firefly" ("I am flying"); the month in which the "fireflies" begin to fly about during the "boshego" or "night."

Eclipses both of the sun ("go fifala ga le-tjatji," *i.e.*, "the turning dark of the sun") and of the moon ("go bola ga kgwedi," *i.e.*, "the becoming rotten of the moon") are regarded as a bad omen.

The *stars* are called "di-naledi." They play a very limited part in the ideas of the Basuto; only those are named which have a practical use in agriculture.

Of the planets, Venus and Jupiter are known.

The last mentioned is called "kgogamashego," or "the drawer up of night."

The best known, however, is Venus. Not realising the identity of the evening and morning star as being one and the same, the Basuto have given her different names.

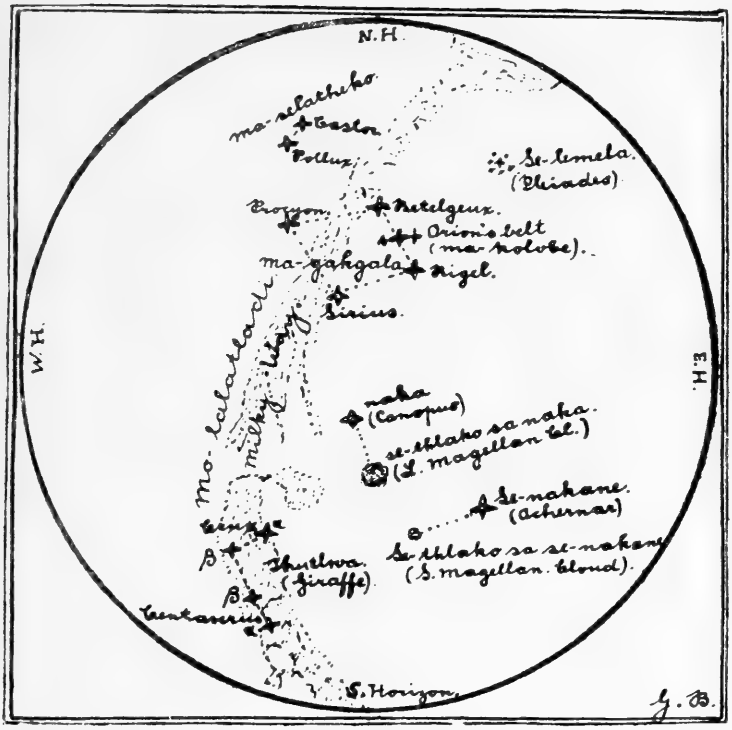
As an evening star she is called "se-falabogogo," that is, "the crust scrapings"; the meaning is that one who arrives by the light of her will get nothing but the scrapings of the pot; or "kopa-dilallo," that is, the one which "asks for supper," because it appears when people have their supper.

As a morning star she is known as "ma-hlapholane," or as

"naledi ea masa," that is, the "morning star." It tells people that the dawn will soon be there!

Of the fixed stars are known Canopus (Alpha Argi); it is called "naka," or "horn," and Achernar (Alpha Eridani), which is called "se-nakane," or "hornlet," diminutive of "naka."

Both stars play an important part amongst the Basuto, as regards the computation of their calendar, especially the former one (Canopus). "E a dishwa," that means: "It is carefully watched" during the time it is expected to become visible (about



The Constellations of the southern sky in the middle of summer, as known to the Basuto.

the end of May). The person who first informs the chief of its appearance gets a gift from him; in olden times he got a heifer as a present. On the very same day the chief calls all his witch-doctors together at his head-kraal; each one has to ask his bone-dice what the new year will bring, good or bad luck, because the old year has passed now and a new one has begun.

Both stars (Canopus and Achernar), in the ideas of the Basuto, have their "shield," which accompanies each of them on its course over the sky. They call it "se-thlako sa naka," or "Canopus' shield," and "se-thlako sa se-nakane," or "Achernar's

shield," and known to us as the large and small Magellanic Clouds.

Of the constellations which bear a name in Suto, the best known is that of the Pleiades. They call it "selemela," that is, the "ploughing constellation," corresponding to "isilimela" in Zulu, because its rising in the early morning of July or August tells the Mosuto that ploughing-time is at hand.

Another constellation known to the Basuto is called "thutlwa,' that is, the "giraffe." It is composed of two stars of the Southern Cross (Alpha and Beta Crucis), and the two pointers to the cross (Alpha and Beta Centauri); the former ones are called the "male" ones ("tshe di-tona"); the other two the "female" ones ("tshe di-thsadi"). If seen low down close to the south-western "horizon" ("mo-napi"), just after sunset, it tells the Mosuto the same thing as the Pleiades, namely, that he must soon start ploughing.

"Ma-gakgala" is another constellation known to the Basuto. It is composed of Alpha and Beta Orionis (Rigel and Betelgeux), and Alpha Canis (Sirius), and Alpha Canis Minoris (Procyon).

Orion's belt is named "makolobe," that is, the "pigs."

The twins, Castor and Pollux, bear the name of "maselatheko."

The Milky Way is known as "mo-lalatladi," that is, the place where the "tladi" bird, "lala" ("rests"). This "tladi" bird is said to cause lightning.

Comets are called "naledi tsha mesela," that is, "stars with tails." When they appear they mean the death of a great chief.

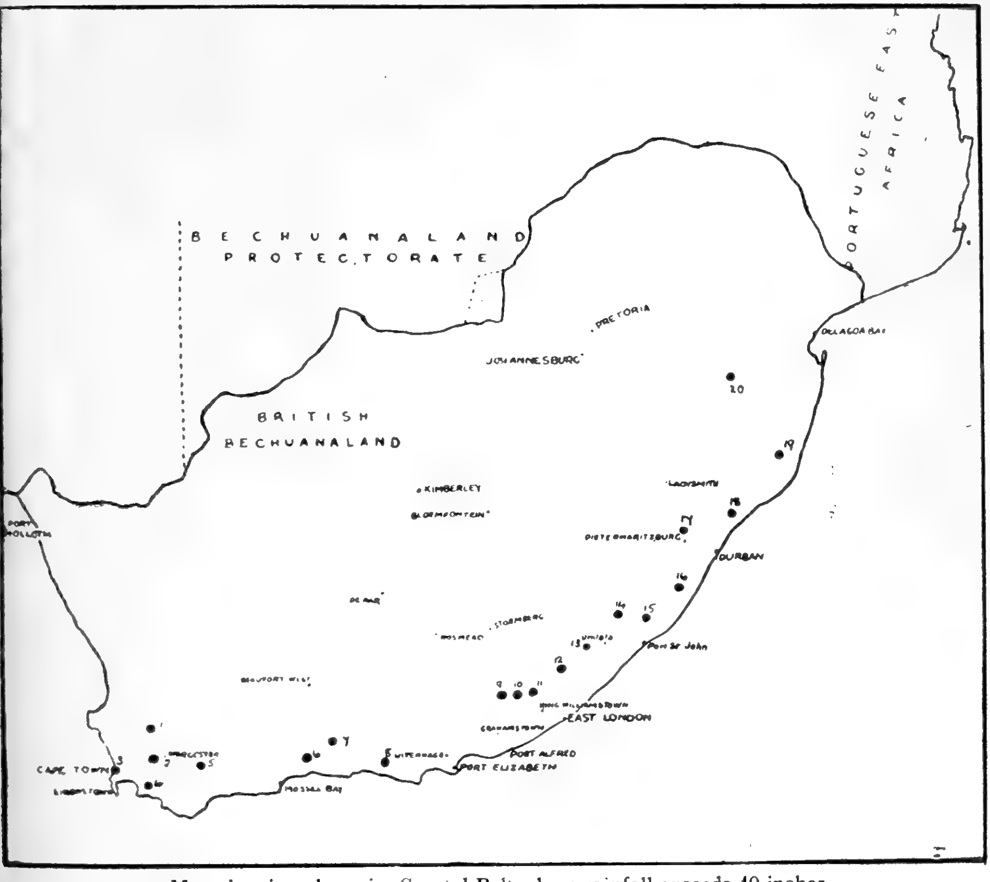
THE POSSIBILITIES AND DEVELOPMENT OF THE COASTAL BELT OF SOUTH AFRICA.

By T. George Caink, M.Inst.M.&Cy.E.

With 1 *Map.*

Read July 10, 1919.

At present in South Africa there are two comparatively small areas producing a large proportion of the wealth of the country. These are the two areas situated around Kimberley and Johannesburg, and the wealth-producing capacity of these two areas is due to Nature having provided the one area with diamonds and the other with gold. The diamond and gold in each is potential wealth only, and is converted into actual wealth by development. Nature has been equally generous to the coastal area by providing it with great potential wealth in a belt of heavy rainfall, at a considerable elevation above sea level,



Map showing places in Coastal Belt where rainfall exceeds 40 inches.

yet comparatively near it. This only needs development to transform it into actual wealth. Before pointing out the immense possibilities of this coastal belt for closer settlement and industrial development, it will be as well briefly to describe it.

As is well known, the coastal belt of South Africa consists of a narrow belt of coast lands rising up a few hundred feet above sea level, hedged in by various mountain ranges forming the escarpment of the great tableland of the interior. This mountain wall comes occasionally within a few miles of the coast, but in other places recedes from 50 to 100 miles away. Along this escarpment there runs right away from Ceres to Zululand a comparatively narrow belt of intense rainfall. This rainfall takes place generally at an elevation on the escarpment of between 1,000 and 4,000 feet. Naturally, the intensest part of this rainfall is on the inaccessible mountain heights, so that we have not many records of the heaviest portion of the rainfall. Nevertheless, we have sufficient records to show that right round the coast from Ceres to Zululand there is apparently a belt of rainfall exceeding 40 inches per annum. The map on p. 211 shows, by circular dots, various spots around the coast where the average rainfall exceeds 40 inches.

TABLE I.

LIST OF RAINFALL STATIONS.

Name of Station.	*Elevation Above. Sea Level.*	*Average Annual Rainfall.*
1. Ceres	1,493	42.0
2. Wemmers and Berg River Hoeks	2,000 Average	90.0
3. Table Mountain	3,300	65.0
4. Elgin	919	45.0
5. Groot Vaders Bosch	1,000	40.5
6. Millwood	1,500	41.0
7. Buffels Nek	2,200	42.5
8. Witte Els Bosch	530	45.5
9. Katberg	3,380	43.0
10. Hogsback	3,752	51.0
11. Evelyn Valley	4,200	70.0
12. Willowvale	—	41.0
13. Baziya	3,000	52.0
14. Tabankulu Forest Station	3,700	51.0
15. Lusikiski Forest Station	—	58.0
16. Port Shepstone	—	45.0
17. Pietermaritzburg, Henley, and Sweetwater	3,000	50.0
18. Stanger		42.0
19. Hlabisa		50.0
20. Mbabane	4,000	55.0

Table 1 gives the list of places shown on the map together with their elevation above sea-level and their average annual rainfall. From this list it will be seen that the 40 inches rainfall usually commences above 1,000 feet above sea level, and increases with the elevation. The few records we have in the coastal ranges, above the 3,000 feet level, show that the rainfall usually exceeds 50 inches. Take, for instance, Wemmers Hoek, Berg River Hoek, Table Mountain, Hogsback, Evelyn Valley, Baziya, Tabankulu Forest Station, and Pietermaritzburg. In looking at the sketch map, there is apparently a gap in the heavy rainfall about Port Elizabeth. But this may be due to lack of records rather than lack of rainfall. In other words, there are no rain gauges kept up in these mountains. This is borne out by the rainfall figures in the Annual Report of the City Engineer for Port Elizabeth for the year 1912, which was about an average year in the district for rainfall. The figures are as follows:—

Sand River Area, Gauge at Reservoir 27.34 inches, average of mountain gauges 42.29 inches. *Bulk River Area,* Gauge at Reservoir, 38.82 inches, average of mountain gauges 45.30 inches. But for these mountain gauges, we should have no information as to there being 40 inches of rainfall in this district.

The distance around the rain-belt line of the Union from Ceres to the Portuguese border is, roughly, 1,000 miles. The author has made a careful study to ascertain the width of this belt of intense rainfall, being personally acquainted with a good deal of the coastal belt, and has gone through a large number of reports and statistics, all of which would take up too much space to include here. The conclusion he has come to is that the width varies from 10 to 30 or 40 miles, and even more in parts of Pondoland and the Transkei. Where the mountains rise abruptly, the width is narrower, but the rainfall more intense. Taking all the facts into consideration, it seems highly probable that there is a belt of country from Ceres to the Portuguese border, at least 20 miles in width, with an average rainfall of 40 inches per annum. Nevertheless, the author proposes in this paper, to be on the safe side, to base his calculations on a belt only 15 miles wide, which gives a total catchment area for this belt of 15,000 square miles.

We have first to consider what is the run-off from this area. For this we possess very little precise information, so the author proposes to take the records of the Perie catchment area of the Buffalo River for the past eight years as the basis for the general run-off of this rain-belt. It may be suggested that the Perie catchment area is abnormal, and that it is not fair to take it as a sample of the rain-belt, but the author knows of no evidence to support this. For instance, if we take the western corner of the rain-belt, we find that Table Mountain gives a run-off three times as great as that of the Perie catchment area, and similar results were obtained from measurements of the run-off from the Berg River and Wemmers Hoek catchment areas. While

there are no doubt some areas with a less run-off than the Perie, there are undoubtedly others with a greater run-off. It may be further suggested that, as our precise knowledge of the coastal rain-belt is so limited, it is risky to make general deductions; this is, of course, to some extent true, but after all we must make our deductions from the knowledge we have, and not from our absence of knowledge.

The catchment area, which supplies Kingwilliamstown with water, is part of the Perie Forest, and is one of the sources of the Buffalo River. It is situated in the heart of this belt of intensive rainfall, the elevation varying from about 1,800 feet above sea level to 4,000 feet, the area being 14½ square miles. Accurate measurements have been kept for the past eight years of the run-off from the catchment area, which will at least give us some positive information to work on.

TABLE 2.

Year.	*Run-off in Million Gallons from Catchment Area above Perie Dam.*	*Percentage of Run-off.*
1911	4,968	32
1912	1,981	17
1913	3,082	26
1914	4,252	31
1915	2,512	23
1916	2,371	23
1917	6,641	39
1918	4,723	38
Total	30,530,	Yearly Average 3,816.

TABLE 3.

PERCENTAGE OF RUN-OFF.

Date.		Average Rainfall for period.	Precipitation in mill. galls.	Run-off in mill. galls.	Percentage of Run-off.
1911	Jan.-May ..	40.64	8,534	3,157	37 p.c.
	June-Aug.	5.06	1,062	355	33 ,,
	Sept.-Dec.	26.68	5,602	1,453	25 ,,
1912	Jan.-May ..	30.87	6,482	1,423	22 p.c.
	June-Sept.	7.80	1,638	155	9 ,,
	Oct.-Dec. ..	17.34	3,641	402	11 ,,
1913	Jan.-March	26.60	5,586	2,127	38 p.c.
	April-July	5.82	1,222	407	33 ,,
	Aug.-Dec. ..	23.37	4,907	548	11 ,,

Date.	Average Rainfall for period.	Precipitation in mill. galls.	Run-off in mill. galls.	Percentage of Run-off.
1914 Jan.-March	28.92	6,073	2,823	46 p.c.
April-July	8.10	1,701	306	18 „
Aug.-Dec. ..	28.83	6,054	1,133	18 „
1915 Jan.-May ..	27.20	5,712	1,981	34 p.c.
June-Sept.	5.50	1,155	172	15 „
Oct.-Dec. ..	19.79	4,155	422	10 „
1916 Jan.-May ..	26.64	5,394	1,712	30 p.c.
June-Sept.	3.51	643	132	20 „
Oct.-Dec. ..	21.02	4,414	527	10 „
1917 Jan.-Dec. ..	80.59	16,923	6,641	39 p.c.
1918 Jan.-March	31.14	6,539	3,604	55 p.c.
April-July	7.31	1,535	603	39 „
Aug.-Dec.	21.18	4,447	516	11 „

Note.—1 inch of rainfall over the catchment area equals in round figures 210 million gallons.

Table 2 gives the total run-off for these years, and Table 3 gives the percentage of run-off for the wet and dry periods during the same time. It will be observed that the percentage of run-off is very high. The greater the rain-fall, the greater the percentage of run-off. In 1917, when there was no dry period during the whole year, there was nearly 40 per cent. of run-off.

In his Annual Report for 1918 the Director of Irrigation gives a table showing the run-off from the Tarka River catchment area for the years 1914-1917, from which I have extracted the information in Table 4, which shows at a glance the difference in the run-off from a typical Karoo area like the Tarka River and a typical coastal rain belt area like the Perie.

TABLE 4.

Run-off per Square Mile in Gallons.

Year.	Tarka River.	Buffalo River.
1914	5,517,000	293,000,000
1915	7,352,000	175,000,000
1916	7,000,000	163,000,000
1917	11,300,000	389,000,000
	31,169,000	1,020,000,000
Average	7,790,000	255,000,000

It will thus be seen that the run-off from the Buffalo River catchment area per square mile is over 30 times as great as the run-off from the Tarka River catchment area, and this may be taken as a general indication of the proportion of run-off per square mile, from what I term the rain belt of South Africa, as compared with the dry interior.

The overflow level of the dam at the Perie is about 1,800 feet above sea level. This may be taken roughly as the average bottom elevation of the rain belt; as a matter of fact, in this district, it probably extends as low as 1,500 feet, and in some parts of the coastal belt as low as 1,000 feet above sea level. But roughly speaking, the contour levels of the rain belt may be taken as lying, roughly, between 4,000 and 2,000 feet above sea level. Most of the water which falls on this rain belt rushes away to the sea, doing very little service to the country, but often doing considerable harm by eroding the steep surfaces. Yet it has great potential value, if properly controlled, so as to become useful to man, a value which can well rival the diamonds and gold of this country. Its potential value is threefold. First, as a source of power; secondly, as a source of irrigation; and, thirdly, as an abundant source of pure water supply for domestic purposes, at a sufficient elevation to supply by gravitation large urban populations along the coast lands.

In dealing with either water for irrigation or power purposes, it is justifiable to base your calculations on the average flow. However, in dealing with domestic water supply, the minimum possible flow must be taken, as a town cannot go without water for a single day. On the other hand, if power-users or irrigators have to be restricted once in five or six years, it is not a very serious matter, and in the case of water used for irrigation, any shortage of water due to a severe drought is probably compensated by increased prices received for the produce.

Power.

It will be seen from Table 2 that the average measured run-off from the Buffalo catchment area above the Kingwilliamstown reservoir is 3,816 million gallons per annum. If this were all stored, and allowing 500 million gallons for loss by evaporation, etc., it would leave 3,300 million gallons per annum to be utilised, or an average in round figures of 9 million gallons per diem. This, in passing from the Perie to the sea, would fall 1,800 feet; but as the distance between the Perie and the sea is about 50 miles, and the fall is more or less uniform, it could not be used in one large power station, but would have to be used in a series of mills every two or three miles down the river, in a similar manner to that in which most of the rivers in England are harnessed, to drive small grinding mills, etc., the tail water of the one mill practically coming out at the level of the head water of the weir below. Anyone acquainted with the West Midlands

of England knows that most of the rivers are utilised in this way, very little fall being lost. On the Rivers Severn and Teme, the loss due to the flow of the water is only two or three inches per mile. With a fall of 1,800 feet in a distance of 50 miles, allowing a fall of 2 feet per mile for the flow of water, it leaves if the river were thoroughly utilised, a fall of 66 feet every two miles. Nine million gallons a day would give a theoretical HP of 125. Allowing 50 per cent. efficiency, including losses in water furrows, etc., it would give in round figures a BHP of 60; so that a factory could be put up every two miles of the Buffalo, from the Perie to the sea, using 60 BHP from this portion of the catchment area only.

The next question to enquire into is the value of this power. In doing this, we must remember that with water power no labour is required whatever, beyond starting and stopping, and occasional oiling. If steam, suction gas, or oil engines were used, the labour of so small a plant as 60 HP is a fairly considerable item. Taking all things into consideration, the author would suggest that ½d. per BHP per hour would be a fair value to put on this power.

It may be argued that if the factories were started in the larger centres of our population, they might be able to get electrical power at less than ½d. per BHP per hour; but in the case of a factory established in a large town, there are many disadvantages to contend with, such as high rates and taxes, high cost of ground, high cost of living, increasing the wages account, and perhaps difficulty in getting water for their manufacturing process; whereas, in this case, they would be on a river.

Further, in a number of manufacturing processes, there are certain odours given off, which, although they may be quite harmless, are objectionable in the centre of a large population. It is probable, therefore, that if a manufacturer were given the choice of obtaining power, say, at ¼d. per BHP per hour in a large centre of population like Johannesburg or Durban, or obtaining the same power at ½d. on a coastal river like the Buffalo, presuming always that there is railway communication, they would in most cases choose a site on a coastal river.

If we take the value at a ½d. per BHP per hour, then 60 BHP per hour will equal £3 a day, or £1,095 per annum. There would be 25 such factory sites between the Perie and the sea; so that the total value of the water power would be £27,375 a year. As previously stated, the catchment area is 14½ square miles, so the value of the power flowing off each square mile would be £1,888 per annum. Taking the total catchment area of the coastal rain belt at the low figure of 15,000 square miles, the value of the power running to waste every year, from this narrow belt only, would be £28,300,000. A sufficiently startling figure to enquire whether it would pay to utilise this power.

In considering this question, the author will again return

to the Perie catchment area, for the reason that it is the only one that he has actual figures to go on.

The chief cost in utilising this power would be the building of a storage dam to equalise the flow throughout the year. A reservoir of 2,000 million gallons' capacity would be sufficient There is no very favourable site for such a reservoir, but a dam could be built to store this water about two miles below the present Perie dam. If constructed on the same plan as the Perie dam, it would cost anything from £80,000 to £100,000; but if built on the new method (rock fill dam, with a reinforced concrete face), lately introduced into this country by the Director of Irrigation, it would probably only cost half the money. (These efforts of the Director of Irrigation to cheapen dam construction are likely to have a far-reaching beneficial effect in utilising our waste water, not only for irrigation purposes, but still more for power purposes.) Nevertheless, supposing it cost the higher figure of £100,000, it would still be a paying proposition, as it would produce an annual value of nearly £30,000 for power alone. But the figures quoted for the Buffalo are for the central catchment area only, above the Perie dam, and do not include four tributaries, all of which join the Buffalo above Kingwilliamstown. Of these tributaries, two are on the west, namely, the Ungquakwebe and Hatchery, and two on the east, namely, the Cwencwe and the Izeleni. The total catchment area of these rivers above the 1,800 feet level is 29 square miles, so that if the whole of the water were stored from this area, allowing the same ratio of run-off, it would give an average daily flow of 27 million gallons from above the 1,800 feet level down past Kingwilliamstown to the sea. A factory could be placed every two miles, using 180 BHP, and the annual value of this power would be £55,000, which at present flows past Kingwilliamstown to the sea without producing a penny.

While the water power of the Buffalo and similar rivers in the eastern part of the country would not lend itself to great power schemes, but rather to small centres of power right down the river, the conditions in the Western Province are usually quite different, and lend themselves much more readily to large power development, as the mountains are more or less flat-topped, like Table Mountain, with precipitous sides, dropping more or less vertically 2,000 or 3,000 feet. When in the employ of the Capetown Council, under the Hydraulic Engineer (Mr. Wynne Roberts), the author made a careful investigation of one of these centres, with a view of supplying power, should the Berg River water scheme have gone through. The area was the tops of the mountain on the west side of the Berg River at the back of the well-known waterfall, which is such a conspicuous feature in the landscape after heavy rains, looking from Paarl towards French Hoek. It includes the peaks known as Africs Kop, Groot Drakenstein Peak, and Spitz Kop. The area is about six square miles, with a minimum elevation of about 2,700 feet

above sea level. The Capetown Corporation had three rain gauges about equally distributed over this area. The average rainfall of these three gauges for the year 1903-1904 was 190 inches. Taking the rainfall for an average year at 150 inches and a run-off of 80 per cent. (careful measurements have shown that the run-off from Table Mountain is well over 80 per cent), this gives a total run-off of 10,400 million gallons per annum, equal to about 28½ million gallons per day. This, falling 2,000 feet, allowing 50 per cent. efficiency, would give about 6,000 BHP per hour. If we take the value of this power at only ¼d. per BHP per hour, we get an annual value of well over £50,000 from this small area. This area is at present drained by about 25 separate streams, falling over and rushing down the steep mountain sides; these would all have to be diverted—which could be done, in most cases, by earth dams—and brought to one central spot to be taken down over the sides of the mountain; in this case probably the waterfall would be the best spot. There are many such areas in the Western Province.

Irrigation.

We must now leave the question of power and turn to our second point, namely, irrigation. The coastal belt offers great advantages for irrigation, over a wide and continuous area, and with it intensive agricultural development, and closer settlement. The following are some of the advantages that the coastal belt offers for irrigation as compared with the dry interior:—

(1) Owing to the wide distribution of rainfall throughout the year, a much shorter period of irrigation is required. This is very important when water has to be pumped.

(2) Owing to the long and heavy rainy season, the subsoil gets thoroughly wet, so that when irrigation is required the depth of water required at each wetting is much less. The author found that two or three inches is sufficient for lucerne, as compared with six inches in the Karoo.

(3) Owing to the wide distribution of the rainfall during the year, the storage capacity for irrigating a given area of land is much less.

(4) Through the poorness of the soil, there is a general absence of conditions which produce brak.

It may seem strange to claim the poorness of the soil as an advantage for the coastal region, but it is a matter of very great importance. The Karoo lands are usually exceedingly fertile, and, under irrigation, will produce their eight or nine crops of lucerne a year, without manuring or fertilising. The coast lands are usually much poorer, and will usually only produce five or six crops of lucerne a year, and then they often require manuring.

Take the district of French Hoek as a coastal area which is largely irrigated. There is no big irrigation scheme in this district; but there are a large number of farms employing irrigation, some using the various perennial streams and rivers, others using small springs on their farms to irrigate their vines, fruit trees, and small patches of land. The farmers complain that these lands require a considerable amount of manuring; but the author has never heard of any mention of brak in the district, nor anywhere else on the poor coastal lands. Altogether, it is far better to manure than to have your lands entirely ruined by brak. The coastal area, owing to its equable climate, usually has a much longer growing period than the interior, and also is able to grow a greater variety of products.

The above conditions offer great advantages for small irrigation schemes, either by pumping water from the perennial streams, or by the construction of small dams across the kloofs on the individual farms. But the conditions do not justify large schemes involving heavy capital expenditure for irrigation alone, as the period during which irrigation is requred is comparatively short. But these are the very conditions to encourage closer settlement and intensive agriculture over a wide and continuous area. As a matter of fact, the most successful closer settlement districts in South Africa are in the coastal areas, such as French Hoek and Groot Drakenstein in the west, and the district of Kingwilliamstown in the east, which is the largest and most successful example of closer settlement in South Africa. Most of the farms in this area range from 30 to 40 acres, usually with commonage rights. Mention need only be made of such places as Keiskama Hoek, Izeli, Isedenge, Hanover, Berlin, Balassi, Frankfort, Stutterheim, etc. There seems no reason why what has been done around Kingwilliamstown should not be extended along the whole coastal area, especially if greater use is made of irrigation.

It might be suggested that "we cannot have our cake and eat it," and that if we use the water for irrigation we cannot use it for power purposes. But in making the calculations for the value of the water power, the author has only taken into consideration the water falling on the narrow rain belt of 15 miles in width, with a rainfall of 40 inches; whereas there is a belt of country from 80 to 100 miles wide, with a rainfall of 20 to 35 inches, and which will give sufficient surplus water for all the irrigation that is required to make this area suitable for closer settlement with intensive development.

Domestic Water Supply.

At first sight there may not seem to be any great potential value in being able to supply large urban populations with abundance of pure water at a low rate. But as we examine it, we shall find it has considerable value. For instance, take

three typical inland towns, Johannesburg, Kimberley, and Bloemfontein, obtaining their water by means of pumping and purification, and compare the cost with three typical coast towns, obtaining their water by gravitation from the mountains, namely, Port Elizabeth, Capetown, and Kingwilliamstown. The average price charged by the three inland towns is 5s. 8d. per 1,000 gallons, and the average price charged by the coastal towns is 1s. 3d. per 1,000 gallons, a saving of 4s. 5d. per 1,000 gallons. On looking forward to the industrial development of South Africa, we ought to take into view a white population of at least ten millions. With a population of ten millions, and taking the consumption of water at 50 gallons per head per day, there would be a saving of £40,000,000 a year, by having the population in the coastal belt, as compared with the inland towns.

Further, although modern science is capable of taking a more or less polluted water and purifying it, so as to make it a perfectly safe, wholesome, and potable water, it is never quite the same as Nature's unpolluted waters, flowing from the rocks of an unpolluted catchment area. And, usually, if the public are given the choice between an artificially purified water and one of Nature's unpolluted supplies, they prefer the latter. This is sometimes said to be mere sentiment on the part of the public, and the author as a youth was a very enthusiastic supporter of artificially purified water; but his enthusiasm considerably abated after being forced to drink, for a year in Nigeria, an artificially perfectly pure water. The water was distilled, and, although every effort was made to aerate it, the author used to think regretfully of the delicious spring water of the Malvern Hills that he used to drink in his school days.

There is no doubt there is something exhilarating in Nature's pure water, which, so far, man has not been able to imitate or the chemist to dissect. It is like flavour in fruit; two fruits may be quite similar—one may have a delicious flavour and the other one not so good. It would probably puzzle the most expert chemist to detect any chemical difference between them; but the youngest child will appreciate the difference in eating. So, while an artificially purified water may be chemically as good and hygienically as wholesome as Nature's pure water, yet there is something elusively delicious about the latter, which makes the drinking of it more delightful to the ordinary man in the street. So that an abundant supply of Nature's pure water by gravitation is not the least of the advantages of the coastal belt for intensive development, and the carrying of large urban populations.

The coastal belt may be taken, on an average, as 100 miles wide, and varying in elevation from sea level to 6,000 feet, so that in this comparatively narrow belt there is a very great variety of climate and vegetable products. Almost every kind of fruit grows prolifically in different parts of the coastal belt, such as bananas, pineapples, pawpaws, loquats, quinces, melons, grapes,

apples, pears, peaches, apricots, figs, nectarines, guavas, almonds, cherries, walnuts, strawberries, Cape gooseberries, mulberries, Japanese plums of all kinds, and citrus fruits of all kinds. Not the least valuable product of the coastal belt is the wattle tree, as, through its rapid growth, it will produce a paying crop in five to seven years, so enabling the ordinary farmer to grow it; whereas most other timber trees, owing to their slow growth, can only afford to be grown by public bodies or wealthy people. There is room for a very large extension of wattle growing in the coastal belt, not so much for its bark as for its timber, as the raw material for distillation, producing such valuable products as pyroligneous acid and methyl alcohol. These are of great importance in many of the arts, particularly in the manufacture of smokeless powder, chloroform, iodoform, creosote, and artificial dyes, and acetic acid, with all its various compounds. Tests recently undertaken by the Imperial Institute, London, have demonstrated that black wattle wood is equal to oak for distillation purposes, the report stating that "the yield of acid is distinctly high." Thus, the black wattle tree should become an important factor in the establishment of industries in the coastal area. After distillation it will leave clean charcoal, etc., as a cheap bye-product to produce exceedingly cheap power, by means of suction gas, for the many industries to spring up in the coastal belt, for which there will not be water power available.

Having considered the potential wealth of the coastal region, we must next consider how this potential wealth is to be converted into actual wealth. The first step the author would advocate is the acquisition of the rain belt by the Government and the removal therefrom of all human habitations, whether European or Native, and the planting of the whole area, which is not at present forest clad, with trees, every care being taken to preserve the springs. This belt should be under the joint control of the Forest and Irrigation Departments. The next step is to build storage dams to equalise the flow-off from this area, and to place the different rivers under some single control, such as a River Board, from their source to the sea. The third step would be to build railways parallel to the rivers, so as to open up industries, worked by the water power.

To see what effect this would have upon the coastal area, we will again take the Buffalo as a typical example. Fortunately, practically the whole of the Buffalo catchment area in the rain belt is forest clad, belonging to the Government; so the first step necessary would be to build sufficient storage reservoirs to equalise the flow. We have already seen that this would give, past Kingwilliamstown, a daily flow of 27 million gallons per day. Thus we should have a splendid, clear, perennial river, the upper reaches stocked with trout, the middle with carp, and the lower reaches with fish coming up from the sea, and with a flow like this the whole river would be plentifully supplied with eels. The storage reservoirs would largely prevent floods; so that, instead

of bridges, few and far between, causeways at a twentieth the cost of bridges could be constructed as frequently as drifts. Every few miles down the river there would be power available to form village centres of industry, connected up by means of a railway with the large industrial centre of Kingwilliamstown on the one side, and the port of East London on the other. The industrial centres would develop around them a number of small farms, intensively cultivated, to supply them with vegetables, butter, cheese, etc. These small farms would be encouraged to build small dams across every available kloof, to conserve sufficient water to irrigate such valuable crops as lucerne and vegetables during the comparatively short, dry periods of the coastal belt. They would also undertake fruit-growing, and so increase the fruit-growing export trade of the coastal area. With cheap sugar, also grown in the coastal belt, they would develop a large export jam trade. The industrial development would be further helped by a supply of cheap charcoal for suction gas from the large and growing wattle plantations of the district.

What would happen in the Buffalo Valley would, no doubt, happen to the whole of the coastal belt, if similarly developed. As an industrial centre, apart from the possibilities of cheap power, the coastal belt of South Africa has four unique advantages, as compared with Europe. Firstly, there is a considerable supply of cheap, unskilled labour; secondly, a combination of sunshine and rain, meaning cheap agricultural production, and therefore cheap living; thirdly, there is easy access to holiday resorts—either the coast on the one side, or the forest mountains on the other—meaning cheap holidays and recreation for the workers; and, fourthly, what is most important of all, easy access to the rich raw materials of tropical Africa, which is so important to modern civilisation. For instance, the palm oil and palm kernels, the ground nut and rubber, the cocoa and cotton, the valuable timber trees, ebony, *lignum vitæ,* mahogany, etc., instead of being shipped by steamers to Europe, could be more cheaply brought by sailing ships and tramp steamers around the coast to the South African ports, to be manufactured in the great industrial area of the coastal belt of South Africa, for export as manufactured articles to all parts of the world. Perhaps one of the greatest future products of tropical Africa will be the supply of the raw materials for the manufacture of the world's paper. As is well known, timber, the present raw material for paper, is being rapidly exhausted. It takes the Northern forests a long time to grow again, whereas the long grasses of tropical Africa are burnt down and replaced every year, forming a permanent supply of raw material for paper-making. If the present natural grasses of tropical Africa are found to be unsuitable for paper making, then it will be necessary to plant these tropical lands with grasses which are suitable.

It is of great importance, for the future of South Africa, that every effort should be made to capture the raw materials

of tropical Africa for the development of South African industries. Every effort should, therefore, be made to reduce the cost of, and make transport easy to the South African towns. In this connection the author would suggest that immediate steps should be taken to consider the question of connecting the great Central African river systems with the South African coast. It seems probable that the cheapest and most practicable method would be to connect the Zambesi River, above the Victoria Falls, with the Limpopo River, via the Chobe River, and a canal cut through the centre of the Okavango swamp, then along the Botletle River, and to follow a contour line around the Makarikari depression, thence across the watershed to join the head of the Shansi River. Owing to the flat nature of the country, it seems probable that it would be feasible to construct a canal from the Zambesi above the Falls, to the south-eastern edge of the Makarikari depression without a lock. It could also be used as an irrigation canal, to irrigate any portion of the Makarikari depression below the contour which may be suitable for irrigation. No doubt very large supplies of water could be obtained by storing the flood waters of the Zambesi, Okavango, etc. The canal through the centre of the Okavango swamp, together with the branch canals, would have the effect of draining the swamp, and turning it into a comparatively healthy fertile country, which could also be irrigated from the same canals by means of pumping.

From all the information the author has been able to gather, the lowest part of the water-shed between the Makarikari depression and the Shansi River is from 3,200 to 3,500 feet above sea level, and the distance down the Limpopo to the sea is about 550 miles; so there would be a fall of slightly over six feet per mile, which would require a lock 20 feet deep every three miles. This is not very excessive, and there are plenty of canals in Europe steeper.

If the weirs across the upper portion of the Limpopo were built a little higher than necessary for navigation purposes, a considerable amount of water would be stored up, equalising the flow, and so making it available for power purposes. The value of the water power would go a long way towards paying the interest on the cost of the necessary constructional works. Such a canal system would tap a very large area of the fertile portion of tropical Africa, including the Upper Zambesi, Kafue, Upper Congo, Lake Tanganyika, the Okavango, etc. Thanks to the low water-sheds separating these different river systems in various places, there would be no difficulty in connecting them up by means of cross-canals, to form one great water system, collecting, by its vast network of rivers and canals, the rich products of tropical Africa. These products would be delivered at a point on the coast, outside the tropics, within a short distance by water of the coastal ports of South Africa, so giving industrial South Africa an immense advantage over Europe.

We thus get a vision of our 85,000 square miles of coastal land as the great industrial centre of the future, carrying a population to the square mile as large as in England, namely, 600. This means a total population of over 50,000,000. As America jumped into a great nation during the nineteenth century, so we may look forward to South Africa jumping into a great nation during the twentieth century, and the first great step is to dam our rivers.

PHYSIOLOGY OF RESPIRATION IN SOME AQUATIC INSECTS.

By S. G. Rich, M.A., B.Sc.

Read July 9, 1919.

The present paper arises out of the apparent attempt of some recent workers to compare the respiration of insects with that of vertebrates.

In vertebrates there is always a double process of respiration. In gills or lungs, or through the skin, the oxygen of the air passes into the blood, where it unites with the hæmoglobin in the corpuscles to form oxyhæmoglobin. The oxygen, thus fixed, is carried to the tissues by the circulation of the blood. Arrived in contact with the cells of various tissues, the oxyhæmoglobin yields up its oxygen for intra-cellular respiration. We thus have two stages in the oxygenation of the cells. In exactly a similar manner, the cells yield up their excreted carbon dioxide to the hæmoglobin, which carries it to the lungs, gills, or skin, through which it diffuses into the air. In saying "air" I here include the air dissolved in water in the cases of gill-breathers.

In all save a few special cases the blood of insects has thus far failed to show the presence of either of the oxygen-carrying substances known to physiologists: hæmoglobin and hæmocyanin. The one definitely proven occurrence of hæmoglobin in an insect is in the familiar "bloodworm" of our streams, the larva of the dipterous insect *Chironomus*. It is possible that the larvæ of some few *Trichoptera* contain hæmocyanin in their deep-green blood.

In connection with the well-known groups of insects possessing tracheal gills, and respiring air dissolved in the water which they inhabit, recent workers have attempted to explain the physiology of respiration. Bodine (1918), working on dragon flies of the family *Agrionidæ*, in the larval stage, showed that the supposed external tracheal gills of this family were not functional. Removal of these alleged gills interfered in no way with the life and metamorphosis of the larvæ. Finding that the rectal tracheation was wholly insufficient to allow of the passage of

gases into the tracheæ through the rectal surface, he assigned respiratory functions to certain tracheated fatty pads found at the anterior end of the lumen of the rectum. With this the present writer has no quarrel, since he found the same pads and had independently assigned them the same function. (Rich, 1918.)

Bodine, however, goes on to say that the carriage of air into the body-cells is not clear; that it may be performed by the blood or through the tracheæ. It is at this point that issue is joined.

The first point of dispute is as to the necessity of postulating the blood as carrier of oxygen to the tissues and carbon dioxide from them. Whoever is acquainted with the anatomy and histology of insects is aware that the tracheal system, a system of ramifying air-tubes, reaches all the tissues much as the circulatory system does in vertebrates. The mechanism for direct respiration of air by each cell, without intermediary, is present. Not only is this true of terrestrial insects, but of water-breathing forms as well. Cullen (1918) has shown that the tracheal branches in the Agrionids pass in fairly large numbers to the skin. This has been noted also in other water-breathing insects, by earlier workers.

It would appear that there is not the least necessity for assuming any other respiratory mechanism to supplement the tracheal system. The rectum is lined with exactly the same material as the skin, namely, chitin. Dewitz (1890) has shown that chitin is permeable to oxygen and to carbon dioxide. There is, therefore, no need to complicate the matter. Through skin and through rectal lining and pads, the gases dissolved in the water pass into the trachea, and the carbon dioxide in the tracheæ diffuse outwards into the water.

The second point of dispute is more vital. In the absence of evidence to prove its presence, we may not assume for the blood and assign to it either the presence of an oxygen-carrying substance or the function of carrier in respiration. It is extremely improbable that two such divergent stocks as the vertebrates and the insects should have the same method of respiratory carriage.

A third objection to allowing the blood any rôle in insect respiration is the nature of the insectan circulatory system. Unlike that of vertebrates, it is not a closed system. It consists of a heart pumping blood cephalad, discharging it into the metacoele or body cavity, and then only of a chaotic series of lacunæ through which the blood oozes, and which are often mere blind pockets of the metacoele. This is certainly a most ineffective mechanism for providing the rapid and continuous supply of oxygen needed for the active life of the insects considered here; but it does suffice for the carriage of nutriment to the tissues. Moreover, the disposition of the tracheæ is

not such as to facilitate the passage of gases into the blood. In such tracheated portions as serve for absorption of gases from water into the tracheæ there is often no blood-cavity whatsoever. The rectal tracheal gills of Anisopterous dragon-flies, as described by many workers, lack these blood-cavities. Sadones (1895), in his classical work upon the morphology of the respiratory organs of a water-breathing insect, shows that the ultimate branches of the tracheæ are imbedded among the cells of the hypodermis in the gills of a dragon-fly larva, and hence as far as possible from contact with the blood.

Dufour (1852) has hit upon an adequate explanation of the respiration of water-breathing insects. Recent advances in physical chemistry enable this to be amplified, and in this modern form I wish to present, as the close of this paper, Dufour's explanation.

Dissolved in the water bathing a tracheal gill are a number of gases, each exerting its partial pressure independent of the others. To some, as oxygen, the chitinous covering of the gill is permeable (the same is true for the skin). These gases pass through it if the pressure of oxygen within the trachea be less than that of the dissolved gas in the water outside. The mere fact that the gas is in solution on one side of the chitinous wall and not on the other does not affect the matter of pressures, for we know on chemical evidence that gases and solids alike behave as gases when in solution.

Whenever the activities of the insect have used up a large part of the oxygen in the air within the tracheæ, more of this gas will diffuse inward through the chitinous covering of the gill, or through the chitinous skin, from the water in which there is a greater pressure of oxygen. Similarly, the activities of the insect soon produce enough carbon dioxide, accumulated within the tracheæ, to be present to generate a large pressure of this gas. Diffusion outwards into the water, poor in this gas, takes place through the chitin.

The active contraction of the abdomen in some aquatic insects that respire through the rectum, the wriggling movements of others, and the varied movements of still others, quite suffice to cause a large movement of the air within the tracheæ. The tracheæ are thus compressed in certain places, and air is forced along the tracheæ into other portions, including the ultimate capillary branches among the cells of the various tissues. As the movements continue, the air circulates, and air rich in carbon dioxide is forced out of the branches into the tracheal trunks. The ordinary diffusion of gases within the tracheæ suffice to make the air throughout the system nearly uniform in composition; accordingly, at any point at which the tracheæ are separated from the water by only a thin chitinous wall, diffusion of carbon dioxide outwards takes place.

Inasmuch as the tracheæ pass through the hæmocœle, it is quite within reason to expect that there will be a certain amount of diffusion of oxygen from the air in the tracheæ into solution in the blood. Similarly, carbon dioxide from the cells of the body will pass into solution in the blood, and thence diffuse into the tracheal air. This process, purely one of solution in the watery plasma which forms the insectan blood, must not be confused with the carriage of air by hæmoglobin in vertebrate blood, nor is it reasonable to suppose that this process plays more than a most subsidiary part in the respiration of insects. The very presence of the minutely ramifying tracheal system precludes this probability.

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NOTE ON A FIND OF "STRANDLOOPER" POTTERY AT DUNBRODY, ON THE SUNDAY'S RIVER.

By Rev. P. STAPLETON, S.J.

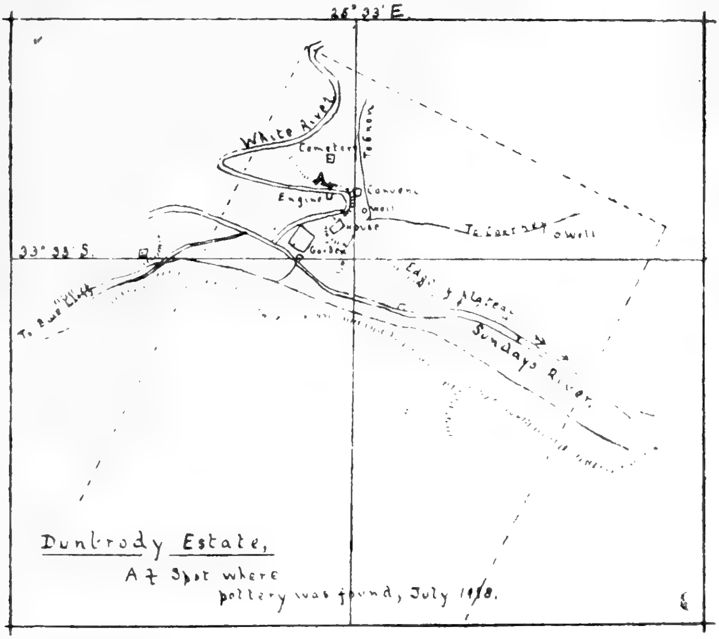
With 2 Figures.

Read July 10, 1919.

In July, 1918, a find of pottery was made, under the circumstances described below, on Dunbrody Farm, in the valley of the Sunday's River.

THE LOCALITY.

About half a mile north of Dunbrody homestead the White River makes a bend at right angles, and flows west along the foot of a cliff for some distance. The place where the pottery described in this paper was found is near the eastern end of this cliff, on the left bank, at a spot almost immediately opposite an engine house used to irrigate the lands, which lie at a lower level on the right bank. (Text-figure 1.)



The cliff above referred to is the edge of the small plateau on which the various buildings of Dunbrody are built. The plateau is composed of some 20 feet of sand and gravel, resting

upon shales or sandstones belonging to the Uitenhage series. It is a typical river formation, showing in its gravel beds water-worn stones of all sizes.

To the south the plateau slopes down to the Sunday's River and becomes identified with the present bank of that river, which exhibits the same intermingling of river gravel and sand.

At the spot where the find of pottery was made, the White River is eating into the cliff-like edge of the plateau, and every flood sees some new portion of the cliff undermined.

Except when in flood, the stream has no such destructive action on the cliff, as its base for some feet above the ordinary water-level consists of hard shale.

Position of the Pottery.

The pottery was found in the face of the cliff, some 20 feet above the water-level and 6 feet from the present top of the cliff. Its presence was first made known by the finding of fragments which had fallen to the base of the cliff.

The deposit itself was a bed of broken shells mixed with fragments of pottery. The bed was only two or three inches in thickness, and occupied a horizontal area estimated at about 6 feet by 3 feet. (Text-figure 2.)

Bank of the White River, at A of plan.

C D shows the shell deposit.

(Sketched from memory.)

Above the deposit was fine sand, which showed a laminated structure.

Nature of the Deposit.

The shells which composed the greater part of the material of which the deposit was made up were exclusively those of the freshwater mussel, *Cafferia caffer* Krss., as identified at the Albany Museum. Some of the shells were calcined and reduced to a white powder. The pottery was scattered among the shells in broken pieces. No stones, which could even probably be identified as artefacts, occurred in the deposit.

The Pottery.

The potsherds recovered belong to two easily distinguishable makes of pottery.

The first kind is yellow in colour, thin and well-baked; the second kind is red or black, thicker and friable.

There is not enough of the yellow ware to enable the size or shape of the vessel to be made out. One vessel of red ware has been sufficiently restored to make conjecture as to its appearance and dimensions feasible. The incised decoration on both types agrees closely with that found on pottery from the shell mounds at Port Alfred. There is a complete pot of this kind in the Albany Museum: it is of the type described and figured by Dr. L. Peringuey as strandlooper.

Conclusions.

It is the opinion of the discoverer that the bed of shells was originally thrown on the surface of the ground, and was subsequently silted over. No trace of disturbance of the ground was visible above the deposit. On the contrary, laminations were traceable in the sand above it. The shape of the deposit, which thinned off at the edges, is in favour of an original heap rather than the filling in of a pit.

On the supposition that the shells were originally laid on a land surface and afterwards covered over by river action, time has to be allowed for the accumulation of at least 6 feet of fine sand, for this is the present height of the top of the cliff above the shell bed.

Again, the White River is now running in a course which is 20 feet lower than the deposit.

Time has therefore to be allowed since the silting up of the deposit for the original stream to abandon its work of silting, and for the same stream, or a new one, the White River, to erode the beds of sand and gravel to the depth of 20 feet or more. So there is at least a presumption of great age for the deposit and its contents.

In connection with this question, it is of interest to note that the freshwater mussel is no longer found alive in the Sunday's River, so far as I could ascertain from the inhabitants of the district.

A NOTE ON THE GENUS FAUREA, HARV.

BY

J. J. KOTZE, B.A., B.Sc. (Dept. of Forests), and E. P. PHILLIPS, M.A., D.Sc., F.L.S. (Division of Botany.)

With 2 Maps and Plates XIII-XVIII.

Read July 11, 1919.

Since the publication of the "Flora Capensis" containing an account of the *Proteaceæ*, we have had an opportunity of examining further material, which extends our knowledge of the distribution of the genus *Faurea* in South Africa. We have also been able to collect data from forest officers in the Union as to the habit, etc., of the species which were not available when the genus was first monographed. This later information, we think, justifies a further note on the genus.

Three of the five known species occur in the Transvaal, viz., *F. Galpinii, F. speciosa* and *F. saligna.* The two former species are endemic, and are found only in the mountainous country of the Eastern Transvaal. The latter species, however, is one of the dominant trees in the Bushveld from Rustenburg to Zeerust, but has outliers in the mountains, and is sometimes associated with *F. speciosa* below the limits of *F. Galpinii,* which appears to be confined to the higher elevations. It is the most widely distributed species of the genus occurring both in the Transvaal and Natal. We have seen a specimen without flowers or fruits collected by Sim in the Egossa Forest, East Pondoland (*Sim* 2446), which he has called *F. saligna.* The shape of the leaves certainly suggests *F. saligna,* but a careful investigation shows

(1) That the lateral veins do not join and form a more or less distinct marginal vein, as in *F. saligna.*

(2) The petioles are glabrous and not hairy, as in young leaves of *F. saligna.*

(3) The young branchlets are glabrous and not hairy, as in *F. saligna.*

These characters, together with the fact that we have seen no authentic specimens of *F. saligna* from the forests in East Pondoland, lead us to believe that this species does not occur further south than Natal.

Faurea natalensis has been recorded from Natal by Gerrard without precise locality, and is evidently confined to the eastern coastal forest belts. Specimens have been collected in the Nenga and Cwebe Forests near St. John's and the Bashee River respectively, and in the Ntsubani Forest in the district of Lusikisiki. The Bashee River appears to be its southern limit, as Miss Pegler does not record it from Kentani, a district she has exhaustively collected in, and no other records are known.

Faurea Mcnaughtonii is known only from Knysna, where it is confined to the Lily Vlei Forest (Gouna), and, as no further information on the distribution of this species has been brought

Faurea galpinii, Phill.

Faurea saligna, Harv.

J. J. Kotze and E. P. Phillips.—A Note on the Genus Faurea, Harv.

to our notice, there is no reason to regard the latter part of the note in the "Flora Capensis"* as incorrect, viz., that Sim was mistaken in recording the presence of this species in the Egossa and St. John's and Pondoland Forests, but that the species referred to by him is *F. natalensis*.

Sim† is also in error when he speaks of there being only 60 trees. Marloth‡ points out that McNaughton estimated the total number at Gouna to be approximately 30,000, and this may be taken as correct. Sim, on McNaughton's authority, further states that it occurs at Blaauwkrantz, Tzitzikama, but the Conservator of Forests at Knysna, Mr. R. Burton, states that he has personally, during the course of a fairly long inspection of the Blaauwkrantz Forest, kept a sharp look-out for this species, but has never come across any trees. He has, moreover, reason for thinking that what has been thought to be this species there is *Pygeum africanum*.

The examination of the further material does not suggest any departure from the key to the species given in the "Flora Capensis" which has been taken over.

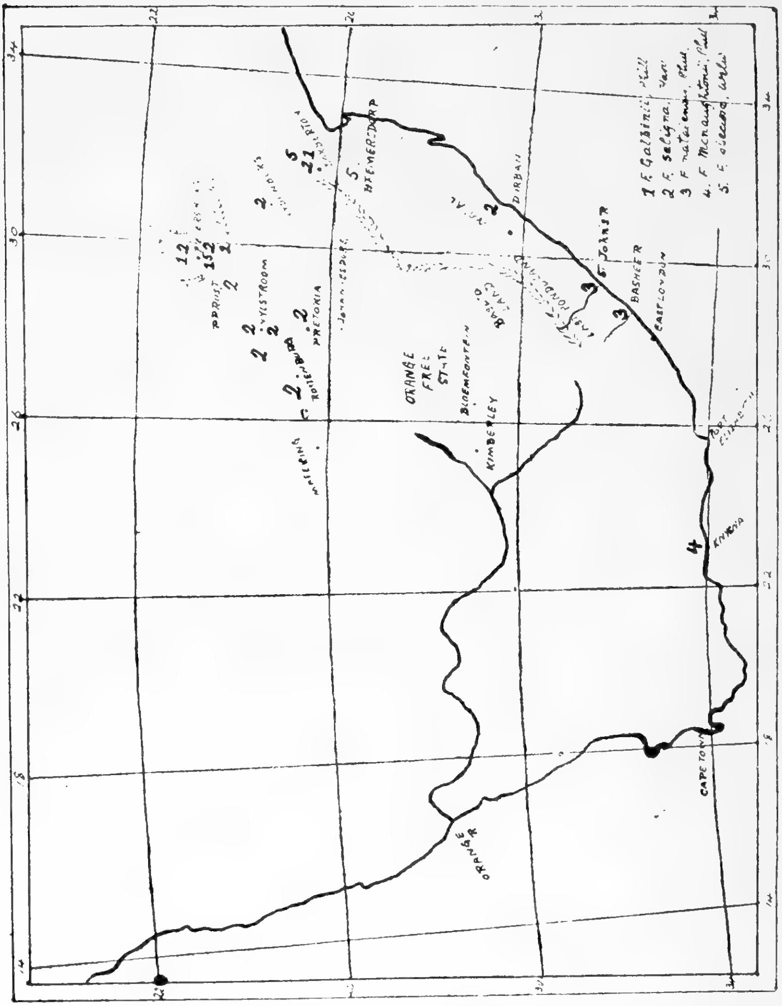
Adult flower-buds 4½-5 lin. long, with a limb up to 1½ lin. long and correspondingly small anthers and stigmas.
  Flowers pedicelled ... ... — 1. Galpinii.
  Flowers sessile ... ... — 2. saligna.
Adult flower-buds 7-10 lin. long, with a limb 2½ to over 3 lin. long, and correspondingly large anthers and stigmas.
  Indumentum of branchlets and spikes very fine, reddish.
  Leaves glabrous.
    Adult flower-buds 7 lin. long, with a rather stout tube and a limb not over 2½ lin. long ... ... — 3. natalensis.
    Adult flower-buds 9-10 lin. long, slender, with a limb to over 3 lin. long ... ... — 4. Mcnaughtonii.
  Indumentum of branchlets and spikes densely greyish-tomentose, that of the branchlets coarse. Leaves tomentose, subglabrous only when quite old.. — 5. speciosa.

* "Flora Capensis," V. 1., 642. He (Sim) remarks on its absence from the Kaffrarian Forests and the Transkei, but says that it is not very rare in the Egossa Forests, and has been seen in St. John's and Pondoland Forests.

† Sim. "The Forests and Forest Flora of Cape Colony."

‡ Marloth. "Flora of South Africa."

1. *F. Galpinii*, Phillips (Fl. Cap., V. 1. 640). Pl. XIII. District Forest Officer O'Connor remarks: "It is a small tree, 15-20 feet high, found mostly on the edge of the forests at the higher elevations. It is abundant in the Wolkberg Forests (near Haenertsberg, Pietersburg), and seems fond of growing in rocky places. The native name is "Magulugulu." It is found asso-



Map showing Species Distribution of *Genus Faurea.*

ciated with "mist belt" forests at elevations of 5,000 feet upwards. Galpin records it as a shrub 8 ft. high.

Distribution.—Barberton Dist.: Margins of woods at summits of Saddleback Mtn. 4800 ft., May, *Galpin* 944. Lydenburg Dist.: Mac.-a-Mac. Falls, 4300 ft., Jan. *Burtt-Davy* 5651, 1453; near Pilgrim's Rest, 4280 ft., Jan., *Burtt-Davy* 5650.

Faurea natalensis, Phill.

Faurea McNaughtonii, Phill.

J. J. Kotze and E. P. Phillips. A Note on the Genus Faurea, Harv.

Zoutspansberg Dist.: Potato Bush, April, *Eastwood* 2435; Woodbush Forests, 5000 ft., March, *O'Connor in Forest Dept. Herb.* 2562; *Legat in Forest Dept Herb.* 454; Shilovane, *Junod,* 5539.

2. *F. saligna,* Harv. (Fl. Cap. V. i. 640). Pl. XIV. According to the Chief Conservator of Forests, Mr. C. E. Legat, the native tree most commonly found at Rooiberg, 40 miles west of Warmbaths Station, on the border of the Waterberg and Rustenburg Districts, is this species. He states: "Naturally, it does not grow to large dimensions. It may reach 20-30 ft. in height, but is crooked and poorly grown. It is remarkable, too, in the number of apparently mature trees which are dead in the veld. Whether this is due to recent years (previous to 1913) of drought, or to other causes, I am not able to determine. It is not likely that fires will be responsible, as this tree has a great power of resisting fires."

District Forest Officer O'Connor remarks that "this species is not found at the higher elevations or not always associated with dense forests, but that it is a tree of the open forests and of the Low and Middle Veld—up to 4000 ft., and that it is often found in dry localities." Galpin records it as a tree 20 ft. high, and Wood as a tree 20 ft. high, branching upright compact.

It is a very common tree in the Daspoort Valley, between the Witwatersrand Range and the Magaliesberg Range. The young branches often have smooth, greyish bark, and the petioles are pink (Phillips).

It is locally known as "Beukenhout," and is used for fence posts, as a wagon wood, for door or window frames, for furniture, etc. It is also said to be fairly ant-resistant.

Distribution.—Pretoria Dist.: Magaliesberg Range, *Burke, Zeyher,* 1480, 1481; Kranspoort, Dec., *Janse in Herb. Transvaal Mus.* 2819. Rustenburg Dist.: *Collins* 137; *Miss Pegler* 1009; Rustenburg, Oct., *Miss Leendertz in Herb. Transvaal Mus.* 9762. Waterberg Dist.: Piet Potgieters Rust, Jan., *Rogers in Herb. Transvaal Mus.* 2256, *Rogers* 329, *Rogers in Herb. Miss Leendertz* 1266; near Nylstroom, Nov., *Burtt-Davy* 2059, 2592, *Nelson* 112; Jan., *Nelson in Herb. Transvaal Mus.* 11754; Warm Baths, Jan., *Burtt-Davy* 5648, Dec., *Burtt-Davy* 2620, *Bolus* 12268. Marico Dist.: *Burtt-Davy* 7574. Barberton Dist.: No collector *in Colonial Herb.* 1746; Kaap River Valley, Barberton, 2200 ft., Dec.-Jan., *Galpin* 868; Barberton, Jan., *Thorncroft in Herb. Transvaal Mus.* 9610. Zoutpansberg Dist.: Magoebas' Kloof, 3000 ft., March, *O'Connor in Forest Dept. Herb.* 2561; Potato bush *Eastwood in Colonial Herb.* 2433; Boekenhout Valley, Dec., *Jenkins in Herb. Transvaal Mus.* 9224; Feb., without collector *in Colonial Herb.* 3433. Natal: Inanda, *Wood* 6, 1189; Zululand, Umzimyati 800 ft., Feb., *Wood* 6369.

3. *F. natalensis,* Phillips (Fl. Cap. V. i. 641). Pl. XV. In the Cwebe Forest this species is known by the native name of "Sefe," and Forester Pretorius, in sending in material (*Forest Dept., Herb.* 2282) remarks that this tree is rare in the Cwebe

and other neighbouring forests, and that it attains a girth of from 60 to 80 inches. The particular tree, however, from which he collected the specimens is an exceptionally large one, and measured 132 inches in girth at breast height, but branches off into two stems at 10 ft. from the ground, each stem about 20 ft. long with a girth of 60 inches. He further states that it is used by native witch doctors for various medicines and as a poison.

District Forest Officer Kaufmann, in submitting material (*Forest Dept. Herb.* 2290), states that he came across only the one tree when marking sections in the St. John's Forest, and it was about 30 ft. high and 12 inches in diameter.

In the Ntsubane area it is known by the natives as "Isefo."

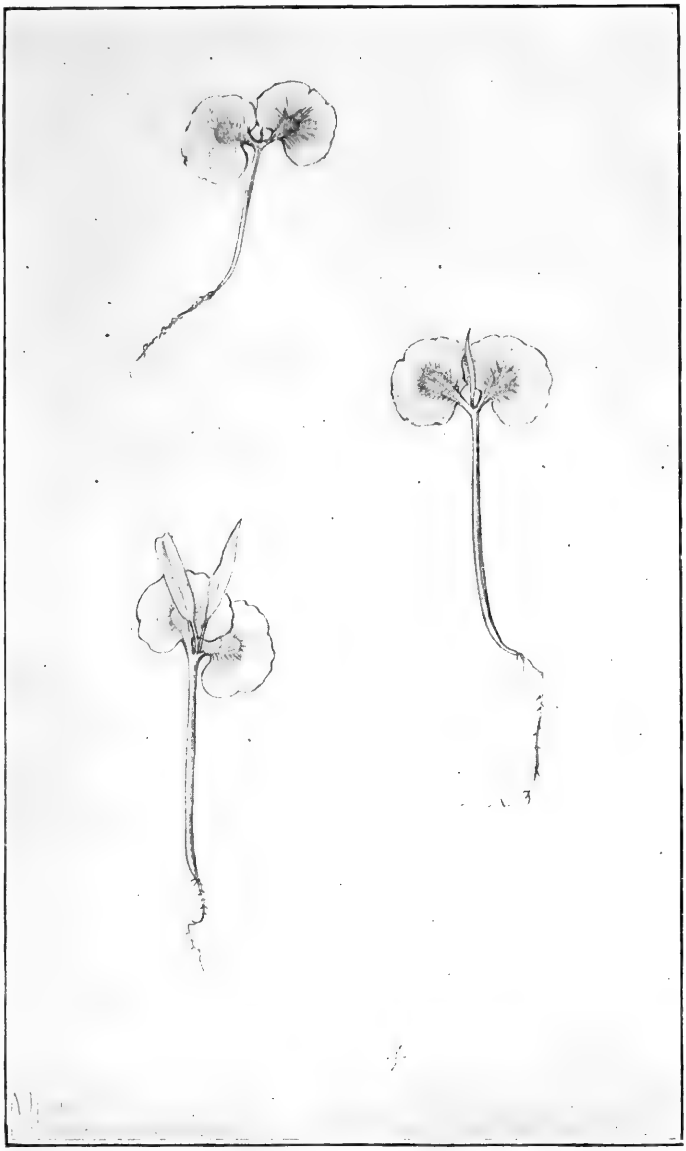
DISTRIBUTION.—Natal, without precise locality, *Gerrard*. Pondoland, Cwebe Forest, Feb., *Pretorius in Forest Dept. Herb.* 2282; Nov. (in leaf only) *Pretorius in Forest Dept. Herb.* 2399; Ntsubani Forest, Jan., *Fraser in Forest Dept. Herb.* 2331; Nenga Forest, Dec., *Kaufmann in Forest Dept. Herb.* 2290.

4. *F. Mcnaughtonii*, Phillips (Fl. Cap. V. i. 642). Pl. XVI. The durability of the timber of this species is remarkable, and compares favourably, in the opinion of District Forest Officer Keet, with that of Sneezewood. It is prized as a furniture wood. District Forest Officer Keet, in submitting flowering material in March, 1919 (*Forest Dept. Herb.* 2694) remarks: "These trees flowered in March-April, 1916, and although a careful search was made in 1917 and 1918, no flowers or seeds could be found until now. The seed ripens and falls soon after flowering; in fact, some trees may still be in full bloom, when seed on others, or from earlier flowers on the same tree, ripens and falls. Germination is free and full, and the forest contains in parts dense crops of seedlings in all stages of growth." Seedlings showing the two cotyledons and the first two leaves are figured on Plate XVII.

DISTRIBUTION.—Knysna Div.: Gouna Forest at Klipkop, near Knysna, *McNaughton in MacOwan Herb. Austro-Afric.* 1948 and *in Herb. MacOwan* 3312; Lily Vlei Forest (Gouna), March, *Keet in Forest Dept. Herb.* 2694; Dec., (seedlings) *Herion in Forest Dept. Herb.* 2376.

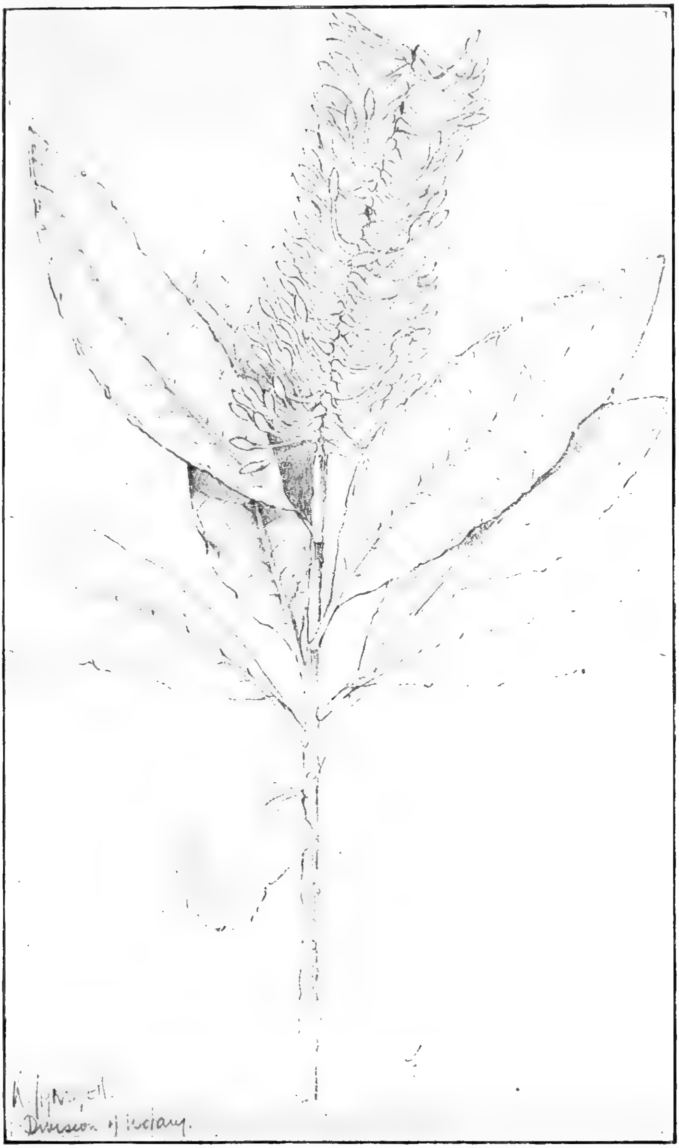
5. *F. speciosa* Welw. (Fl. Cap. V. i. 642). Pl. XVIII. This is a small to medium tree, found, according to District Forest Officer O'Connor, on the foothills below forests in the North-Eastern Transvaal. Thorncroft notes: "A tree 20-25 ft. high. Trunk crooked, seldom straight. Branches thick, few. Unlike ordinary sugar-bush, but branching 12-15 ft. from the ground." Galpin records it as a tree 10-15 ft. high.

DISTRIBUTION.—Barberton Dist.: Barberton, without collector *in Colonial Herb.* 3405; Barberton, May-June, *Thorncroft*, 806, 622, and *in Herb. Transvaal Mus.* 4346, *in Natal Govt. Herb.* 10406; Reimer's Kloof, near Barberton, among bush, near summit of first ridge, June, *Burtt-Davy* 356; mountain sides,



Young Seedlings of *Faurea McNaughtonii*, Phill.

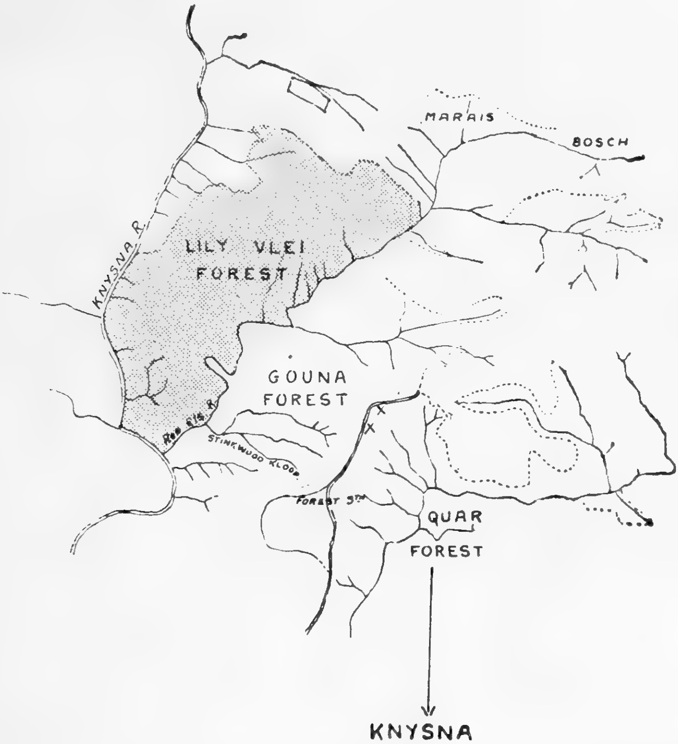
J. J. Kotze and E. P. Phillips.—A Note on the Genus Faurea, Harv.



Faurea speciosa, Welw.

Barberton, 2800-4000 ft., May-July, *Galpin* 402; Elands Hoek, Sept., *Rogers in Herb. Transvaal Mus.* 2585; Barberton, *Bolus* 9756 and without collector *in Forest Dept. Herb.* 457. Zoutpansberg Dist.: Common on hills close to Haenertsberg, *Legat in Herb. Transvaal Dept. Agric.* 1269; Tzaneen, Nov., *Mogg in Govt. Herb* 10092; Woodbush, *Mrs. Barber* 2; Woodbush, Sept., *Jenkins in Herb. Transvaal Mus.* 7193; Middlekop, 4000 ft., Nov., *O'Connor in Forest Dept. Herb.* 1462.

District Forest Officer Keet forwards us the following note on this species:—



Sketch Map illustrating the Distribution of *Faurea McNaughtonii*.

"In regard to the distribution, or rather the supposed occurrence, of "Terblonz" in the Transkei, I remember that Mr. Ross, Acting Chief Conservator of Forests, has a bookcase made out of timber obtained from one of the forests in Pondoland, and which he told me was the "Knysna" Terblonz. He purchased the wood in the forests, and, if I remember rightly, knew the tree in the forest from which the timber was sown. It may be that this was really *F. natalensis*, but the timber certainly appears dead similar to Terblonz, and I think you should refer to him in connection with this matter.

I may perhaps further explain the distribution of *F. Mcnaughtonii* at Knysna, and in order to do so more clearly enclose for your information a tracing of the divisional map, on which you will find the *Lily Vlei Forest* marked. The dotted line indicates the perimeter of the forest, and you will note that the forest is bounded on the east, south and west by the Knysna and Red Els Rivers respectively. The former river runs in a gorge 600-800 ft. deep with sides mostly precipitous, but nevertheless wooded in both sides down to the water's edge. The lower part of the Red Els is as deep, but the sides less steep and better wooded (or timbered), while the upper portion is but 300-400 feet deep. The stream is only an ordinary mountain torrent.

Now, with exception of three or four large trees and a fair regrowth around them in seedling and sapling stages, at the points marked with crosses on the road leading northwards from the forest station, no other trees of this species are known at present outside Lily Vlei Forest, and the two rivers, therefore, would seem to have effectively stopped the distribution of this tree. It is just possible that there may be a few specimens in the part of the forest between the road above referred to and Lily Vlei Forest, but thus far I have not found any. This is no doubt strange in face of the excellent regrowth of the species in Lily Vlei Forest, and I ascribe this to the following causes:—

(1) The seed does not appear to be eaten by birds, and is therefore dependent on wind and water transportation.

(2) It is not sufficiently winged, in comparison to weight and size, for wind transportation over long distances.

(3) In so far as water transportation is concerned, the seed falls during autumn and early winter, when rains are good but light, and the seed germinates so quickly and freely that there is not much chance of it being washed away by floods.

(4) During autumn our winds are moderate. Strong (Bergwinds) commence in June only, as a rule."

INSECT ENEMIES OF THE CODLING MOTH IN SOUTH AFRICA AND THEIR RELATION TO ITS CONTROL.

By F. W. Pettey, B.A., Ph.D. (Cornell).

Plates XIX-XX.

Read July 11, 1919.

Bairstow, in the "Cape Agricultural Journal" (1893), vol. 6, pp. 82-84, reported having bred an Ichneumon fly, *Pezomachus* nov. sp., in a breeding cage containing codling infested pears and apples. This is the earliest report of a parasite of *C. pomonella* in South Africa. Lounsbury mentions having bred *Pimpla heliophila* Cam. and *Hymenobosmina pomonellæ* Cam. from codling larvæ in 1906. The Spanish parasite, *Calliephialtes messor,* was brought by Mr. C. W. Mally from California to South Africa in 1907. In 1909 both Mr. Lounsbury and Mr. Mally found an egg parasite of *Carpocapsa pomonella,* which ultimately was named *Trichogrammatoidea lutea* Girault.

In the study of the codling moth at Elsenburg and Sauer's orchard the following insects were discovered to be of assistance in controlling the codling moth:—(1) Predaceous—Gryllidæ: *Liogryllus bimaculatus* Geer. Reduviidæ: *Pirates* sp., *Coranus papillosus* Thunb. Pentatomidæ: *Diploxys hastata* Fabr. Carabidæ: *Chlænius dichrous* Wied. Formicidæ: *Dorylus helvolus, Iridomyrmex rumulis* Mayr. (2) Parasitic—Chalcidoidea: *Trichogrammatoidea lutea* Girault, *Chalcis* sp. Ichneumonidæ: *Pimpla heliophila* Cam., *Trichomona cariniventris* Cam., *Pimpla* sp.

The Egg Parasite, *Trichogrammatoidea lutea* Girault.

History.—Among the several parasitic enemies of the codling moth in South Africa there is only one of great importance in the control of this insect, namely, the Chalcid, *Trichogrammatoidea lutea.* This parasite was discovered by Mr. Claude Fuller in 1901 to breed in the eggs of the so-called Natal codling moth, *Enarmonia batrachopa,* a native insect injurious to oranges in Natal and the Transvaal. In 1909 Mr. Lounsbury and Mr. Mally bred this egg parasite from codling moth eggs in Constantia and Uitenhage. Mr. J. C. Faure bred the parasite from codling eggs in the Free State in 1917. Consequently the writer infers that the insect is now distributed generally over South Africa.

Girault, of the University of Illinois, found that this parasite was a new species of the family Trichogrammatidæ, and gave it the above-mentioned name in 1911. The original description may be found in the "Transactions of the American Entomological Society" (1911), vol. 37, pp. 19-22.

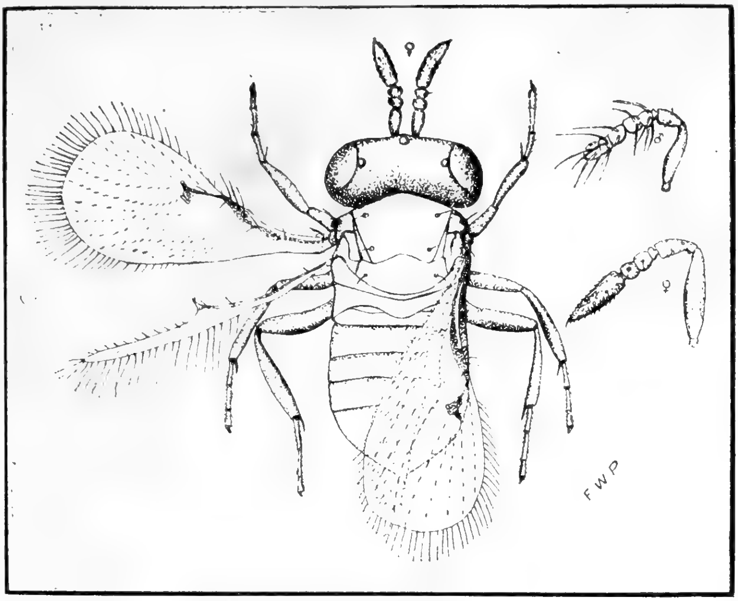
This parasite is evidently indigenous to South Africa, and probably existed by breeding in the eggs of the native moth, *Enarmonia batrachopa*, before the introduction of codling moth into the country. The writer has found that the parasite will breed also in a pear slug egg.

Description of the Adult.—The following description of the insect was made from alcoholic specimens. The dorsal aspect of a female is illustrated in Plate XIX (*a*).

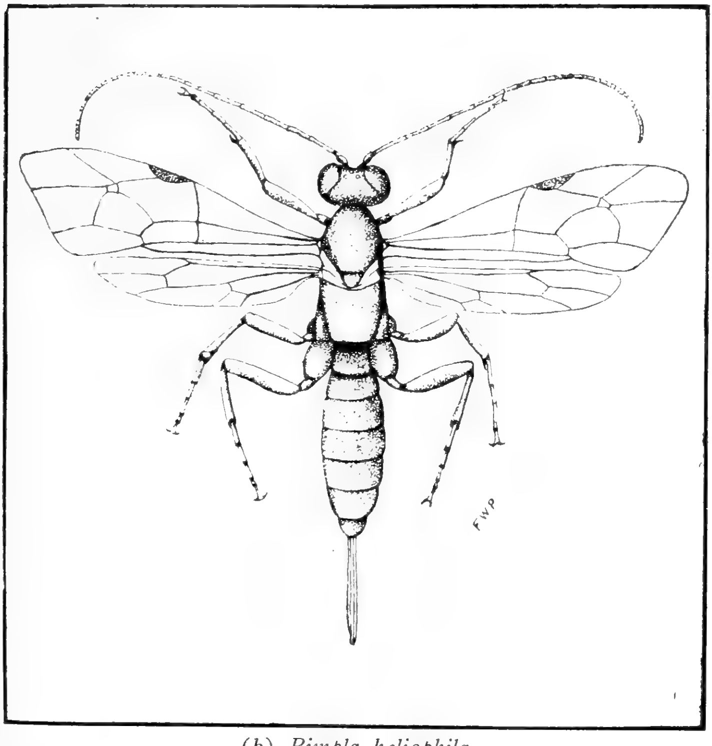
Female: Length .7 to .9 mm., varying in size according to the number which emerges from a codling egg. General colour yellow, with dusky brown markings. Head yellow, eyes and ocelli carmine, front below eyes dusky yellow. Thorax: pronotum and prescutum dusky yellow to brown; tegulæ dusky brown, scutel dusky yellow with anterior margin black; scapula and propodeum yellow. Abdomen dusky yellow, with the anterior third darker. Antennæ yellow, scape somewhat paler, sparsely setose. The relative length of the antennal segments may be expressed by the following ratio: Scape 12, pedicel 5, funicle joints 1, ring joints 2.8, 2.8, club 9. Legs: coxæ dusky yellow to brown, front coxæ lighter, trochanters, femora, and tibiæ pale yellow, tarsi dusky yellow, claws darker. Wings hyaline, margined with long hairs except proximal half. Forward wings: proximal area fumated from the base to the middle of the marginal vein on the forward margin, and to a point 1/3 of the distance from the base to the apex on the hind margin; minute hairs of forward wings arranged in about 12 longitudinal rows; the fumated area, except near its outer margin, and a circular area caudad of the stigmal vein have no hairs; the hairs near the hind margin of the wing rather irregularly arranged; marginal vein thickest and shortest, containing 2 long setæ; submarginal vein longest, and thicker at the distal third, containing 1 long seta; stigmal club with claw containing about 3 alar sensoria. Hind wings narrow, with angular evagination at distal end of submarginal vein, which bears 2 hooklets; marginal hairs of the hind and outer margins much longer than those of the anterior margin of the wing, and a little longer than the longest of the forewings.

The male may be distinguished from the female chiefly by the structure of the antennæ, the funicle of the former sex, with the exception of the ring joint (annulus), having prominent long setæ and the club consisting of three segments.

Trichogrammatoidea lutea may be distinguished from *Trichogramma minutum*, the common codling egg parasite of the United States, by the fact that the forward wing of the latter has a transverse row of small hairs extending caudad from the stigmal club, and scattered small hairs between the longitudinal rows of small hairs. The antenna of the male *T. lutea* has a club of only one segment, which is joined to the funicle segments.



(*a*) *Trichogrammatoidea lutea.*



(*b*) *Pimpla heliophila.*

F. W. Pettey.—Insect Enemies of the Codling Moth in South Africa and their Relation to its Control.

THE DEVELOPMENT OF *Trichogrammatoidea lutea* IN A CODLING EGG.—Several codling moths were enclosed in a bell-jar with glass slides upon which rested small pieces of cotton, soaked in sugar and water solution to attract the moths to the slides. Three codling eggs, marked (*a*), (*b*), and (*c*) respectively, were laid on the glass slide on the night of February 10. Several parasites were placed on February 12 in a glass tumbler, together with the three eggs on the slide. A parasite was seen ovipositing in egg (*c*) on the morning of February 13, after which the parasites were removed. Eggs of the parasites were indistinctly visible as minute oval forms in the codling eggs when they were examined with the microscope on the night of February 13 by means of reflected artificial light (see Plate XX). The appearance of the codling eggs and the development of parasites within them are indicated in the following diary, and observations as seen through the microscope are illustrated in the drawings of Plate XX showing egg (*a*) much enlarged.

February 13, 9 *p.m.*—As illustrated in Plate XX (*b*), representing codling egg (*a*), each codling egg has five concentric circular areas, the outer comprising only the transparent shell with irregular netted ridges. The middle circular area is composed of opaque more or less pentagonal cells filled with an olive-coloured granular substance, and bordered on the inner margin by an irregular circular ring of red pigment. The inner area is almost as light and transparent as the outer ring, and contains cells similar in texture to the middle area, but not so closely packed, and hence more spherical. In the middle area of (*a*) are five indistinct minute oval olive-coloured eggs, three in (*b*), and two in (*c*). These are the eggs deposited by the parasites. Others possibly are present, but are not visible.

February 14, 9 *p.m.*—Codling egg (*a*). See Plate XX (*c*). The eggs of the parasite have hatched in the codling egg, thus showing that eggs of *T. lutea* hatch in about 24 hours or less. The parasite larvæ are eight in number, four distinctly larger than the others. They take up the whole of the central and middle circular areas as described above, so that now there appears to be only two circular areas in the codling egg, an inner and an outer zone. The red granular pigment has now become distributed in small quantities, and forms practically an outer border for each larval parasite. The pigment is evidently absorbed by the parasites. The larvæ, viewed through the codling egg-shell, are more or less rectangular in shape, owing apparently to pressure. The embryo cells of the developing codling larva, as described in the codling egg February 13, have disappeared, and the parasites appear as granular olive-shaped masses of small circular cells, practically immovable except at the narrower or head end, which sways slightly laterally, and has a pulsating movement. The head end of one lies by the head end

of another only in one case. All the larvæ are living, as is indicated by the movement.

Codling egg (*b*). Four large and two small parasite larvæ are in the codling egg. Their appearance is similar to that of egg (*a*).

Codling egg (*c*). Four large parasite larvæ are in the codling egg.

February 15, 9 *a.m.*—Codling egg (*a*) appears the same as the day before in colouring and texture. Only six larvæ are visible. Note in Fig. (*d*) that the largest of February 14 are not necessarily the ones that survived. This is determined by the position of the head end in each examination. The margins of the parasite larvæ are slightly darker in colour, caused by the accumulation of very fine black granules, probably the result of a beginning of the breaking down of cells previous to the transformation stage.

Codling egg (*b*) is in practically the same state as on February 14.

February 16, 9 *p.m.*—Codling egg (*a*) see Fig. (*d*). The larvæ are still active at the interior ends. The red pigment has practically disappeared. It is indistinct and appears to be scattered through the larvæ. A peculiar addition is the presence of numerous circular small black cellular bodies in each larva. This probably represents a breaking down of the tissues previous to the transformation of larvæ into pupæ.

Codling eggs (*b*) and (*c*): The larvæ are in the same state as those in egg (*a*).

February 17, 9 *p.m.*—There is practically no change.

February 18, 9 *p.m.*—Codling egg (*a*), see Plate XX (*c*). There is no longer any movement in the larvæ. The parasites have become darker, due to accumulations of fine black granules, and are distinctly oval in shape and slightly smaller. They have lost the characteristic larval form. The small back circular bodies are still evident, but less in number and concentrated near the centre. A little red pigment is still evident in the parasite. This is evidently the prepupal stage of the parasite.

Codling eggs (*b*) and (*c*): The larvæ have become prepupæ, as in egg (*a*).

February 19, 9 *p.m.*—Codling eggs (*a*), (*b*) and (*c*): The larvæ have now changed to pupæ, as indicated by a pair of compound, red eyes in each (see Fig (*f*)). Wings are evident in one pupa.

February 20, 9 *p.m.*—The heads are more distinct, and the compound eyes more conspicuous.

February 21, 9 *p.m.*—Codling egg (*a*): In pupa number 3 three ocelli are evident.

Codling egg (*b*): Ocelli are evident in one pupa and wings are evident in two pupæ.

Codling egg (*c*): Ocelli and wings are quite evident in all.

February 22, 9 p.m.—Codling egg (*a*): There is no change. Codling egg (*b*): The two smallest pupæ have shrunk and probably have died. Codling egg (*c*): Pupæ are in the same condition.

February 23, 9 p.m.—Codling egg (*a*): There is no change. Codling egg (*b*): The adult parasites have emerged. Codling egg (*c*): There is no change.

February 24, 9 p.m.—Codling egg (*a*): Parasite number (6) is moving and trying to make its exit by movements of legs and feelers, pressing the body against the codling egg shell. Codling egg (*b*): One more adult parasite has emerged, and another is attempting to do so. Codling egg (*c*): At 11 a.m. all the adult parasites have emerged from the codling egg except one, which attempts to make its exit by movements of the head and feelers. There are only two openings in the shell of the codling egg. Apparently a parasite emerges by simply breaking the codling egg shell through pressing the head or body against it.

February 25th, 9 p.m.—Codling egg (*a*): Adult parasite number (6) has ceased to attempt to emerge, and has died. Parasite number (3) is an active adult, and is struggling to emerge. Codling egg (*b*): Two pupæ have died.

February 26, 9 p.m.—Codling egg (*a*): Parasite number (3) has emerged. The rest have died in the pupal stage.

The results of the observations of the development of *T. lutea* in a codling egg show that the incubation period of the egg was less than 24 hours, the larval stage comprised about 3 days, the prepupal stage was about 1 day, and the pupal stage was from 4 to 5 days. Under out-of-doors conditions the stages would probably be longer or shorter, depending on the temperature.

Egg-Laying Observations.—Table 1 records observations showing the influence of the number of insertions of an egg parasite's ovipositor in a codling egg on the number of parasites emerging from a parasitized codling egg.

The parasite was enclosed in a test tube with numbered codling eggs which had previously been laid on a leaf. The insect was observed under a binocular microscope.

In laying, the position taken by the insect was as follows: The antennæ were directed downward with the exception of the basal segment, which was directed forward. The tibia of each leg was directed backwards. The femur of the two front legs was directed forwards. The insect's body took the position of an angle of about 35° with the surface of the codling egg.

As soon as the parasite was placed with the eggs in a test tube, she immediately walked to codling egg No. 17, walked over it a few seconds, feeling about the margin with the tips of her antennæ, apparently to be certain of directing the oviposition in or near the centre. As the records illustrate, the parasite sometimes inserted her ovipositor several times in a codling

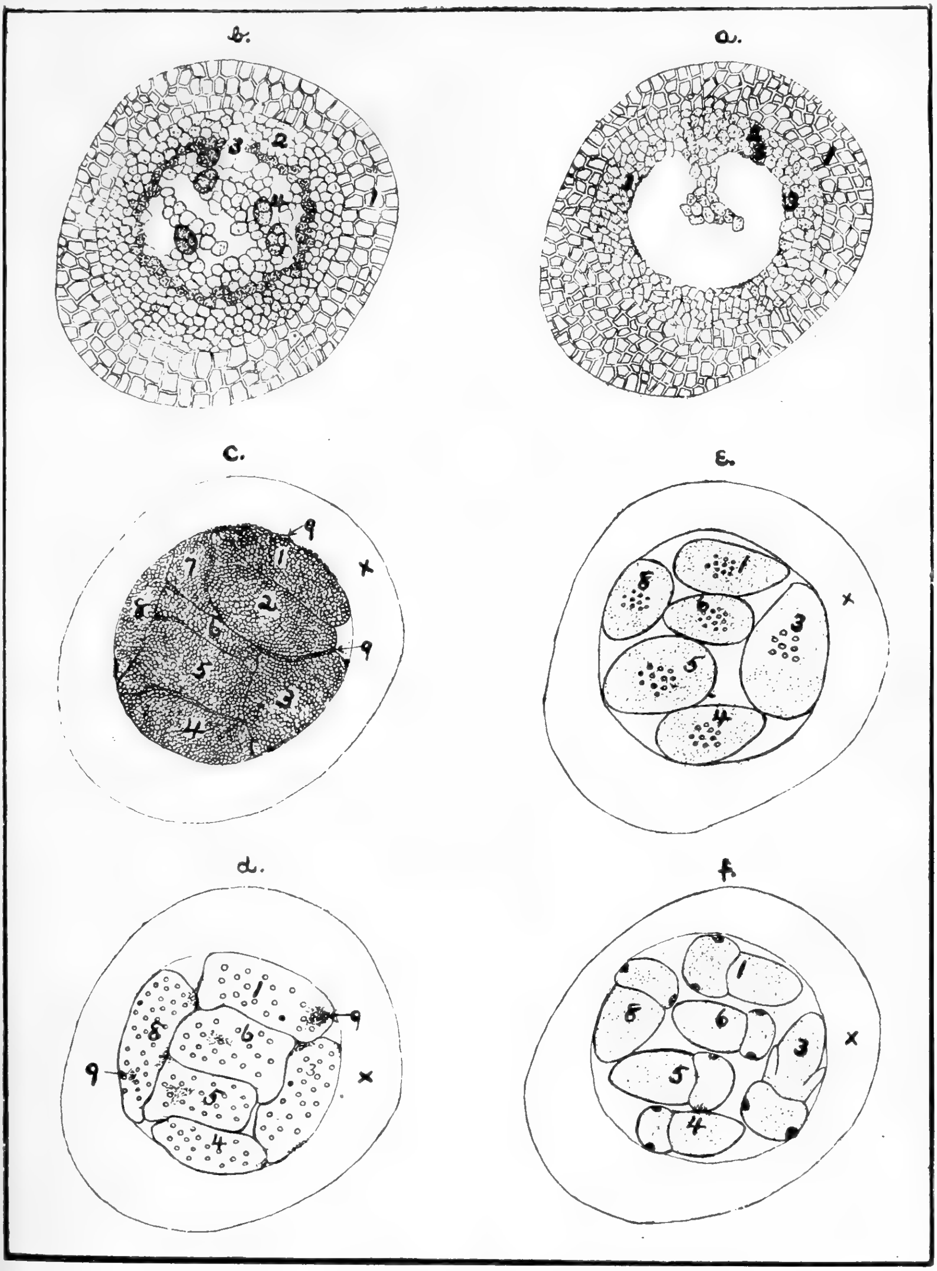
egg before going to another. Occasionally the parasite would rest a few minutes after an insertion, before beginning work again. After the fourth insertion in egg 17 the parasite left the egg, walked around about a minute, apparently looking for another egg, and then returned and attempted for a few seconds to insert the ovipositor again, but failed. Between each insertion the insect walked over the egg, feeling around the whole margin with her antennæ as if she were turning on a pivot. She often attempted to insert the ovipositor and failed, after which she would feel around the margin again with the distal segment of her antennæ. After a seventh insertion in egg 17 she went directly to egg 16, inserted the ovipositor seven times in this egg, and then proceeded to egg 18, and afterwards to eggs 19, 9, 3, 1, 21, 2, 4, and 12 in succession. The later ovipositions apparently required more time than the earlier ones. Other observations revealed that the parasite would sometimes leave one egg, insert the ovipositor in another, and then return to the former and insert again, apparently not being aware of the fact that the egg was previously parasitized by oviposition. However, the parasite generally proceeded very methodically from one egg to another, as if her primary object in life were to parasitize as expeditiously as possible a maximum number of codling eggs for the benefit of the fruit grower.

Results show that the codling eggs penetrated the greatest number of times by a parasite's ovipositor produce the most parasites. Polyembryony evidently does not exist.

Parasitization of Codling Moth Eggs.—A summary of Table 2, containing records of the number of eggs parasitized by individual female parasites, enclosed in a test tube with a definite number of freshly laid codling eggs, shows that one female *T. lutea* will parasitize as many as 18 codling eggs.. The greatest number of parasites emerging from a codling egg was 7. The greatest number of progeny of the first generation arising from a single female adult parasite was 41 individuals, the life-cycle of which may be as short as 9 days.

To determine how many parasites will emerge from a parasitized egg under field conditions, 20 parasitized codling eggs were collected at random through the orchard. It was subsequently found that as many as six parasites may emerge from a single codling egg in the orchard. It was found by microscopic examination that sometimes parasites will fail to emerge from the codling egg; they sometimes die as pupæ in the codling egg, while others fail to break the egg-shell of their host and therefore die of starvation.

Table 3 records parasitization observations of 6,664 codling moth eggs exposed on trees in the Elsenburg orchard during the summer of 1915-16. Codling moths emerging from the flower pots of the breeding room were enclosed in muslin on the branches of a Kieffer pear tree at intervals through the



Development of *Trichogrammatoidea lutea* in Codling Moth Egg.

summer. After three or four days the muslin was removed, the surviving moths were killed, and the eggs were then exposed. Parasitization was determined by the colour of the codling eggs, black indicating parasitization. It will be noted that no eggs were parasitized until November 9. Little parasitization occurred until about the middle of December, after which there was a rapid increase, until finally from January till about the end of the fruit season an average of over 90 per cent. of the codling eggs was destroyed by this natural enemy. This great increase in parasitization was possibly partly due to the fact that the laying of most of the codling eggs was concentrated on one tree of the orchard. Those codling eggs resulting from moths of January 9, 10, and February 4, were laid in other parts of the orchard a considerable distance from the above-mentioned tree. It will be noted in the table that the parasitization of these eggs was a little less than 50 per cent. Observations of this nature in 1916-1917, carried out in the same place, show, as recorded in Table 4, that parasites did not appear until December 11, over a month later than in the previous year.

Conclusions from the Study of *T. lutea*.—Results indicate that *Trichogrammatoidea lutea* has little influence on the control of the first generation moths, but much is done to control the later broods, since the parasite directly prevents the hatching of about 50 per cent. of the codling eggs from mid-summer to the end of the fruit season. Evidently much may be done to control the later generations of moths by concentrated breeding of the parasite. Its short life-cycle and many generations during the summer season, its fairly large laying capacity, and the tendency of one female to infest as many as 18 codling eggs, make the potential powers of this parasite great in controlling the codling moth. By the concentration of codling eggs for the parasite, more opportunity is given to it in order to lay its maximum number of eggs in a maximum number of eggs of the host.

Other Parasites of the Codling Moth.

Pimpla heliophila Cam.—Next in importance to *T. lutea* as a parasite of the codling moth is the Ichneumon, *Pimpla heliophila* Cam.; bred from codling larvæ and pupæ by Mr. C. P. Lounsbury in 1906. This insect was named and described by Cameron in the "Transactions of the South African Philosophical Society," vol. 16, pp. 337-339. The adult is illustrated in Plate XIX (*b*). Seventy-three individuals were bred from 2,824 codling larvæ collected from Sauer's orchard at approximately 10-day intervals. Doubtless in those orchards where collections of larvæ from bands is not practised the parasite is more abundant, since destruction of codling larvæ by trapping also destroys the immature individuals of this parasite.

Calliephialtes messor.—This parasite, which had previously

been reported as a formidable enemy of codling larvæ in Spain, was introduced into South Africa by Mr. Lounsbury, and was brought from California by Mr. C. W. Mally in 1907. The parasite was liberated in considerable numbers the following year in Fransche Hoek and Stellenbosch orchards. The writer failed to rear a single one from 600 codling larvæ, collected in the Fransche Hoek orchard from the bands of the unsprayed badly infested trees during 1915-1916. Evidently the parasite had succumbed to its new conditions.

Other parasites, mentioned previously, were found in negligible quantities.

THE ARGENTINE ANT AND ITS RELATION TO CODLING LARVÆ.

In the year 1916 several Argentine ants were incidentally discovered in Le Roux's apple orchard, Stellenbosch, eating a codling larva. Investigations were subsequently made to determine the relation of the Argentine ant to codling moth in orchards infested by both.

Forty codling larvæ were placed above a hessian band on the trunk and branches of an apple tree where Argentine ants were present. Almost immediately the ants began to attack, with the result that in 20 to 30 minutes all had dropped from the tree but four, 22 dropping by letting themselves down by a thread when touched by an ant, while the rest rolled off by wriggling when attacked. The four larvæ left on the trunk were attacked and held there by ants, and in three hours they were dead, while two of these were two-thirds eaten by the ants. Forty ants were eating one worm, while 22 were eating another. At the end of three hours eight of the larvæ dropped to the ground had disappeared, while the rest were being attacked by many ants. They were doubtless killed eventually. One larva crawled into a hole in the bark, but in 20 minutes had wriggled out again because of ant bites.

In 1916-17 more attention was given to the question of the influence of the ant on codling moth. Banding tests were made in a pear orchard, and in Roux's apple orchard, where ants existed. To determine the effects of the presence of the ant on the trapping of worms in bands, sprayed fruit-bearing apple and pear trees were supplied each with a single hessian band to provide an attractive place or shelter for the codling larvæ, at the same time allowing the numerous ants to pass up and down the trees. Other neighbouring trees, bearing approximately the same number of fruits, were supplied, each with a single band, a few inches below which a band of tree tanglefoot was placed around the trunk to prevent ants from climbing the trees, and at the same time to allow codling larvæ leaving the fruit on the trees to pass down the tree into the band. The pear orchard was not nearly as badly infested with Argentine ants as the apple orchard. Hundreds of ants were constantly in the bands of the apple trees, passing up and

down the trunks, while only a small stream of the insects was travelling up and down the trunks of the pear trees and through the bands. The ants were apparently attracted to the pear trees by *Pseudococcus capensis*, a mealy bug which was infesting the pear fruits. The apple trees were infested with woolly aphis, which attracted the ants. The apple orchard was irrigated during the whole of the fruit season, shallow ditches leading the water from one tree to another. Water flowed through these ditches at intervals of a few days. The remainder of the time they were moist, during which period ants swarmed in the ditches, apparently being attracted by the moisture, and being led to the trees by means of connecting ditches.

Table 5, recording the banding experiments, shows that in the bands of the apple trees, over and under which many ants constantly passed, only one larva was collected from January 16 to February 13; 72 larvæ were gathered in the same period in the bands of those trees to which ants were prevented access by a tanglefoot barrier. In the bands of the four pear trees, over and under which comparatively few ants were constantly passing, 62 larvæ were captured from January 16 to February 2; in those trees to which ants were prevented access 104 larvæ were captured.

Six large apple trees, loaded with fruit, in the Le Roux orchard were banded during the whole season, and were examined about every month. Only a total of four larvæ was discovered in these bands during the whole season. The owner of this apple orchard claims and is reputed to have his fruit comparatively free from codling infestation every year, although he sprays his large trees only with small knapsack pumps. It was noted by the writer, during 1916 and 1917, that this orchard was much more free from codling than neighbouring ones, where irrigation was not practised, and where *Iridomyrmex humilis* was not so abundant.

Results show that the banding of trees is not effective in capturing codling larvæ where the Argentine ant visits the trees constantly in large numbers. This ant appears to be of considerable use in the control of *Carpocapsa pomonella* in orchards where it is very abundant on the trees during the fruit season.

Notwithstanding the effectiveness of *Iridomyrmex humilis* in codling control under the above-mentioned conditions, it is inadvisable to encourage the increase of this insect, which in many respects causes injury, directly or indirectly, to the fruit-grower.

Liogryllus bimaculatus Geer as an Enemy of Codling Larvæ.

Crickets, identified by Dr. Peringuey, of the Capetown Museum, as *L. bimaculatus*, made their first appearance of the fruit season in the codling bands on January 8, and were present from that date until the end of the fruit season, gradually increasing in number and reaching a maximum during the last

week of January and the first two weeks of February. The presence of these insects in the bands suggested the possibility that they were predaceous on codling larvæ. To determine if this were a fact crickets were confined in flower pots, and a definite number of codling larvæ was supplied daily. The records may be found in Table 6.

These records, and other observations, show that the crickets do not eat much for a few days before they moult. The adults ate more larvæ during February when the weather was warmer. One cricket was seen to devour its exuviæ after it had moulted, and on another occasion a female cricket devoured its mate. This indicates that the species is predaceous on other animals, which prevents it from becoming a very efficient enemy to codling in the field. The enclosed crickets will devour pupæ as well as larvæ.

Comparative records of collections of codling larvæ and crickets from individual trees for several weeks show that a great number of crickets in the bands does not seem to have an influence on the number of larvæ in the bands, thus indicating that the crickets do not destroy many codling larvæ in the field. The records in Table 7 illustrate this hypothesis. It will be noted that those bands from which the largest number of larvæ was collected contained the smallest number of crickets.

The Effectiveness of *Coranus papillosus* Thunb., a Reduviid, as a Predaceous Enemy of Codling Larvæ.

This insect was first observed in the bands on December 16, and was present in considerable numbers until the fruit was harvested. Several were discovered during the season, sucking the liquid from the codling larvæ, which they had penetrated by means of their proboscides. The insect, which is said to be common in the Western Province, was identified by Dr. L. Peringuey.

To determine the efficiency of this Reduviid as an enemy to codling, six adults were confined in a glass jar, and a definite number of larvæ was supplied daily, with the results shown in Table 8.

The records indicate that this Reduviid is not as effective economically as the cricket. The records in Table 7, which show that the greatest number of bugs was in those bands which trapped the greatest number of larvæ, further substantiate this statement.

Conclusions Regarding the Effectiveness of Natural Enemies in Controlling the Codling Moth.

Predaceous and parasitic enemies of the codling moth cannot be relied upon satisfactorily to control the codling moth, especially because they begin their beneficial work too late in the season. No matter how efficient a parasite might be in the

control of this insect, there would always be certain years when the host would dominate the parasite in numbers, a fact that is true of every parasite and host, and the fruit-growers would have lost enough in years of diminution of parasites to more than offset the expense that they would incur by spraying for this insect. *Novius cardinalis*, in its relation to the control of *Icerya purchasi*, is an exception to this rule. The fact that *Novius cardinalis* is so successful in the control of *Icerya purchasi* is because the injurious effects of the Australian bug act slowly on the host plant, and by the time that the several years of dominance of the bug, necessary to do appreciable damage, have elapsed, the parasite is again abundant. The codling larva, however, produces immediate injury, and therefore requires more immediate attention than a parasite will supply.

DESCRIPTION OF PLATE XX.

Diagrammatic drawings of codling egg (*a*), much enlarged. The egg-shell has been removed from those areas where the codling embryo or parasites are developing.

Fig. 1 (*a*).—Appearance of codling egg (*a*) about 12 hours after it has been laid.
- 1. Shell area, showing ridges and hexagonal areas.
- 2. Cells of forming codling embryo.
- 3. Red pigment beginning to appear.

Fig. 1 (*b*).—Appearance of codling egg (*a*) February 13, three days.
- 1. Codling egg-shell area.
- 2. Developing codling embryo cells.
- 3. Red pigment area.
- 4. Egg of parasite under embryo cells.

Fig. 1 (*c*).—Appearance of codling egg (*a*) February 14, 9 p.m., showing 8 larvæ of Chalcid parasite.
- x. Codling egg-shell area.
- 1-8. Young Chalcid parasite larvæ.
- 9. Red pigment surrounding Chalcid parasite larvæ.

Fig. 1 (*d*).—Appearance of codling egg (*a*) February 16, 9 p.m., showing apparent reduction in numbers of the Chalcid parasites.
- x. Codling egg-shell area.
- 1, 3, 4, 5, 6, 8. Chalcid parasite larvæ with black cell-like circular rings.
- 9. Remains of red pigment.

Fig. 1 (*e*).—Appearance of codling egg (*a*) February 18, 9 p.m., showing parasite larvæ in prepupal stage.
- x. Codling egg-shell area.
- 1, 3, 4, 5, 6, 8. Chalcid parasites in prepupal stage. The characteristic larval form is lost.
- The parasites are black in colour, due to an accumulation of fine black granules.

Fig. 1 (*f*).—Appearance of codling egg (*a*) February 19, 9 p.m.
- x. Codling egg-shell area.
- 1, 3, 4, 5, 6, 8. Parasites in pupal stage. Number 3 shows wings as well as other pupal characters.

TABLE I.

Records showing the Influence of the Number of Insertions of a Parasite's Ovipositor on the Number of Parasites emerging from a Parasitized Codling Egg.

Number of Eggs.	Insertion of Ovipositor of the Parasite in the Codling Egg.	Length of Time of the Insertion of the Ovipositor.	Number of Parasites emerging from the Codling Egg.
17	1st insertion	5 minutes	7
...	2nd ,,	1 ,,	...
...	3rd ,,	4 ,,	...
...	4th ,,	3 ,,	...
...	5th ,,	$3\frac{1}{2}$,,	...
...	6th ,,	$\frac{1}{2}$,,	...
...	7th ,,	4 ,,	...
16	1st insertion	7 minutes	3
...	2nd ,,	3 ,,	...
...	3rd ,,	2 ,,	...
...	4th ,,	$2\frac{1}{2}$,,	...
...	5th ,,	2 ,,	...
...	6th ,,	2 ,,	...
...	7th ,,	$2\frac{1}{2}$,,	...
18	1st insertion	$2\frac{1}{2}$ minutes	5
...	2nd ,,	2 ,,	...
...	3rd ,,	$2\frac{1}{2}$,,	...
...	4th ,,	$2\frac{1}{2}$,,	...
19	1st insertion	$1\frac{1}{2}$ minutes	?
9	,, ,,	3 ,,	3
3	,, ,,	9 ,,	2
1	,, ,,	4 ,,	4
21	,, ,,	6 ,,	2
2	,, ,,	6 ,,	2
4	,, ,,	7 ,,	3
12	,, ,,	5 ,,	Egg dried up

TABLE 2.

Parasitization of Codling Moth Eggs by *Trichogrammatoidea lutea.*

Parasitization by	No.	Codling Moth Eggs.				Female Parasite E.				
		Laid.	Parasitized?	Hatch.?	Incubation.	Oviposition in codling egg.	Progeny of parasites emerges.	No. of parasites emerging	Life cycle of parasite progeny	Remarks.
									days	
Parasitization by parasite E.	1	Jan.31	Yes	No	..	Feb. 2	Feb. 11	2	9	
	1	,,	,,	,,	..	,,	,, 11	*2	9	*1 dead pupa.
	1	,,	,,	,,	..	,,	,, 12	3	10	
	1	,,	,,	,,	..	,,	,, 12	3	10	
	1	,,	,,	,,	..	,,	,, 12	4	10	
	1	,,	,,	,,	..	,,	,, 12	3	10	
	1	,,	,,	,,	..	Feb. 3	,, 13	4	10	
	1	,,	,,	,,	..	,,	,, 13	3	10	
	1	,,	,,	,,	..	,,	,, 13	2	10	
	2	,,	,,	,,	..	,,	,, 2	3	10	
	2	,,	,,	,,	..	,,	,, 11	4	9	
	24	,,	No	Feb. 5	5 days	..	..	..	..	
Parasitization by parasite F.	1	Feb. 4	Yes	No	..	Feb.5,6	Feb. 15	2		
	1	,,	,,	,,	..	,,	,,	3		
	1	,,	,,	,,	..	,,	,,	4		
	1	,,	,,	,,	..	,,	,,	3		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	Feb. 16	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	Feb. 15	2		
	1	,,	,,	,,	..	,,	,,	*3		*1 dead pupa.
	1	,,	,,	,,	..	,,	Feb. 17	1		
	1	,,	,,	,,	..	,,	,,	1		
	1	,,	,,	,,	..	,,	,,	1		
	1	,,	,,	,,	..	,,	Feb. 19	1		
	1	,,	,,	,,	..	,,	,,	*3		*2 dead pupae.
	1	,,	,,	,,	..	,,	,,	2		
	8	,,	No	Feb. 10	6 days	..	..	..		
Parasitization by parasite G.	1	Feb. 4	Yes	No	..	Feb.5,6	Feb. 15	2		
	1	,,	,,	,,		,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	2	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	Feb. 16	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	Feb. 17	*2		*1 dead pupa.
	27	,,	No	Feb. 10	6 days	,,	..			
Parasitization by parasite H.	1	Feb. 4	Yes	No	..	Feb.5,6	Feb. 15	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	3		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	Feb. 16	2		
	2	,,	,,	,,	..	,,	,,	3		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	3		
	1	,,	,,	,,	..	,,	,,	2		
	1	,,	,,	,,	..	,,	,,	1		
	1	,,	,,	,,	..	,,	,,	*2		*1 dead pupa.
	1	,,	,,	,,	..	,,	Feb. 15	3		
	1	,,	,,	,,	..	,,	Feb 17	*2		*1 dead pupa.
	1	,,	,,	,,	..	,,	Feb. 19	2		
	8	.	No	Feb. 10	..	,,	..	..		

TABLE 2—*continued.*

Parasitization	Codling Moth Eggs. No.	Laid.	Parasitized?	Hatch.	Incubation.	Female Parasite E. Oviposition in Codling Egg.	Progeny of Parasite emerges.	No. of Parasites emerging	Life Cycle of Parasite progeny	REMARKS.
Parasitization by Parasite B.	1	Jan. 29	Yes	No	—	Jan. 30	Feb. 10	4	2 days	
	1	,,	,,	,,	—	,,	,, 10	2	3 ,,	
	1	,,	,,	,,	—	,,	,, 9	2	3 ,,	
	1	,,	,,	,,	—	,,	,, 10	3	2 ,,	
	1	,,	No	Feb. 4	6 days	—	—	—	—	
	1	,,	,,	,,	,,	—	—	—	—	
	1	,,	Yes	No	—	Jan. 30	Feb. 10	*2	2 days	*1 dead pupa.
	1	,,	,,	,,	—	,,	,, 11	2	2 ,,	
	1	,,	,,	,,	—	,,	,, 10	3	2 ,,	
	1	,,	,,	,,	—	,,	,, 10	3	2 ,,	
	1	,,	No	Feb. 4	6 days	—	—	—	—	
	1	,,	,,	No	—	—	—	—	—	
	1	,,	,,	Feb. 4	6 days	—	—	—	—	
	1	,,	Yes	No	—	Jan. 30	Feb. 11	2	2 days	
	1	,,	,,	,,	—	,,	,, 11	2	2 ,,	
	1	,,	,,	,,	—	,,	,, 10	3	2 ,,	
	1	,,	,,	,,	—	,,	,, 10	7	2 ,,	
	1	,,	,,	,,	—	,,	,, 10	5	—	
	1	,,	No	Feb. 4	6 days	—	—	—	—	
	1	,,	,,	,,	,,	—	—	—	—	
	1	,,	Yes	No	—	Jan. 30	Feb. 10	2	2 days	
Parasitization by Parasite A.*	1	Jan 26.	No	Feb. 1	6 days	—	—	—	—	
	1	,,	,,	,,	,,	—	—	—	—	
	1	,,	,,	,,	,,	—	—	—	—	
	1	,,	Yes	No	—	Jan. 28	Feb. 8	1	3 days	
	1	,,	No	Feb. 1	6 days	—	—	—	—	
	1	,,	,,	,,	,,	—	—	—	—	
	1	,,	Yes	No	—	Jan. 28	Feb. 8	2	*2 d'ys	*1 dead pupa.
	1	,,	,,	,,	—	,,	,,	3	2 ,,	
	1	,,	,,	,,	—	,,	,,	1	2 ,,	
	1	,,	,,	,,	—	,,	,,	2	2 ,,	
	2	,,	,,	,,	—	,,	,,	2	2 ,,	
	2	,,	,,	,,	—	,,	,,	5	2 ,,	
	2	,,	,,	,,	—	,,	,,	7	2 ,,	

NOTE.—Parasite A may have parasitized more codling eggs, as it was removed after the above eggs were parasitized.

SUMMARY.

Parasite.	Codling Eggs exposed to Parasite.	Codling Eggs Parasitized.	No. of Parasites emerging from Codling Eggs.
E	37	13	32
F	25	17	33
G	35	8	17
H	28	18	39
B	21	14	41
Total ..	146	70	162
Average ..	29*	14	32*

TABLE 3.

Parasitization of Codling Moth Eggs by the Chalcid Parasite, *Trichogrammatoidea lutea.*

Date of			Number of Eggs		
Enclosure of Moths on Pear Branch	Egg Exposure	Examination of Eggs	Total	Parasitized	Not Parasitized
Nov. 4	Nov. 8	Nov. 16	82	0	82
,, 9	,, 12	,, 20	102	3	99
,, 9	,, 13	,, 21	70	0	70
,, 9	,, 13	,, 21	40	0	40
,, 9	,, 13	,, 21	48	0	48
,, 9	,, 13	,, 21	50	0	50
Oct. 28	,, 2	,, 10	320	7	313
,, 28	,, 2	,, 10	25	0	25
,, 25	Oct. 29	,, 8	6	0	6
Nov. 8	Nov. 12	,, 23	140	0	140
,, 8	,, 13	,, 23	115	0	115
,, 1	,, 4	,, 12	53	0	53
,, 1	,, 4	,, 12	167	0	167
,, 5	,, 10	,, 22	6	0	6
,, 5	,, 10	,, 23	50	0	50
,, 4	,, 8	,, 15	68	0	68
Oct. 25	,, 1	,, 8	92	0	92
,, 19	Oct. 25	,, 7	38	0	38
Nov. 1	Nov. 4	,, 12	21	0	21
,, 2	,, 5	,, 13	102	0	102
,, 12	,, 15	,, 24	183	0	183
,, 12	,, 16	,, 25	231	0	231
,, 25	,, 28	Dec. 4	15	0	15
,, 20	,, 24	,, 3	12	0	12
Dec. 1	Dec. 3	,, 12	40	0	40
,, 18, 19	,, 22	,, 29	69	9	60
,, 20	,, 23	Jan. 1	34	0	34
,, 20	,, 24	,, 2	302	71	231
,, 21	,, 25	,, 2	172	54	118
,, 25	,, 28	,, 3	103	43	60
Jan. 2	Jan. 6	,, 12	229	114	115
,, 3	,, 7	,, 14	244	208	36
Dec. 30	,, 3	,, 11	209	120	89
Jan. 2	,, 6	,, 21	220	207	13
,, 5 (*a*)	,, 9	,, 21	172	97	75
,, 5 (*b*)	,, 9	,, 21	135	125	10
,, 6	,, 10	,, 21	206	125	81
,, 8	,, 12	,, 26	151	97	54
,, 9	,, 14	,, 24	385	175	210
,, 10	,, 14	,, 26	291	161	130
,, 17	,, 20	Feb. 2	162	152	10
,, 20	,, 23	Jan. 31	151	144	7
,, 20	,, 24	Feb. 1	172	170	2
,, 28	,, 31	,, 10	292	261	31
Feb. 4	Feb. 7	,, 15	119	10	109
,, 18	,, 23	Mar. 2	156	150	6
,, 5	,, 9	Feb. 20	331	310	21
Jan. 29	,, 1	,, 11	183	145	38

Table 4.

Parasitization of Codling Eggs by the Chalcid Parasite, *Trichogrammatoidea lutea.*

Date of			Number of Eggs.		
Enclosure of Moths on Pear Branch	Egg Exposure	Examination of Eggs	Total	Parasitized	Not Parasitized
Nov. 1	Nov. 8	Nov. 15	520	0	520
,, 3	,, 8	,, 18	308	0	308
,, 5	,, 10	,, 20	50	0	50
Oct. 26	,, 2	,, 12	85	0	45
,, 24	,, 1	,, 10	210	0	210
Nov. 9	,, 14	,, 20	75	0	75
,, 12	,, 18	,, 25	5	0	5
,, 10	,, 14	,, 21	120	0	120
Dec. 11	Dec. 14	,, 20	46	21	25
,, 14	,, 18	Dec. 27	318	32	285
,, 19	Jan. 2	Jan. 10	173	127	46

Table 5.

The Influence of the Argentine Ant on the Collection of Codling Larvæ from Bands.

Pear Trees, Ida's Valley.						Apple Trees, Stellenbosch.					
Trees Banded, no Tanglefoot			Trees Banded, Tanglefoot.			Trees Banded, no Tanglefoot.			Trees Banded, Tanglefoot.		
Tree.	No. of larvæ.	Date collected	Tree.	No. of larvæ.	Date collected	Tree	No. of larvæ.	Date collected	Tree	No. of larvæ.	Date collected
1	12	Jan. 26	1	28	Jan. 26	1	0	Jan. 26	*1	3	Jan. 26
2	6	,,	*2	14	,,	2	1	,,	*2	5	,,
3	9	,,	3	11	,,	3	0	,,	*3	2	,,
4	13	,,	4	18	,,	4	0	,,			

* A few ants were present. They climbed the trees by means of grass which touch the branches. Pear Tree No. 2 showed 4 of the larvæ in the upper portion of the tanglefoot; they had evidently been driven by the ants from the band into the tanglefoot.

1	7	Feb. 2	1	8	Feb. 2	1	0	Feb. 2	1	6	Feb. 2
2	4	,,	2	13	,,	2	0	,,	2	14	,,
3	6	,,	3	9	,,	3	0	,,	*3	4	,,
4	5	,,	*4	3	,,	4	0	,,			

* Tree 4. A few ants were present; they climbed the tree by a blade of grass touching a branch.

* Tree 3. A few ants were climbing the tree, having made a tunnel through a crack under the tanglefoot.

1	0	Feb 13	1	15	Feb. 13
2	0	,,	2	12	,,
3	0	,,	3	11	,,

Pear Trees		Apple Trees	
Total No. of larvæ from banded trees	62	Total No. of larvæ from banded trees	1
Total larvæ from banded trees and tanglefoot	104	Total No. of larvæ from banded trees and tanglefoot ..	72

TABLE 6.

Record of Two Crickets in the Nymph Stage, confined with Codling Larvæ, February 9, 1917.

No. of Larvæ Supplied.	Date Larvæ were Supplied.	Date of Examination.	No. of Larvæ Eaten.	No. of Larvæ not Eaten.	REMARKS.
4	Feb. 9	Feb. 13	1	3	
4	,, 13	,, 14	1	3	
4	,, 14	,, 15	1	3	*1 cricket became adult Feb. 15.
*4	,, 15	,, 16	3	1	
4	,, 16	,, 17	3	1	
4	,, 17	,, 18	4	0	
6	,, 18	,, 19	5	1	
6	,, 19	,, 20	5	1	
6	,, 20	,, 21	6	0	
8	,, 21	,, 22	5	*3	*The 3 not eaten were killed.
8	,, 22	,, 23	6	*2	*1 not eaten was killed.
8	,, 23	,, 24	4	4	
6	,, *24	,, 25	3	*3	* The other cricket became adult Feb. 24.
6	,, 25	,, 26	4	2	
6	,, 26	,, 27	4	2	*3 — 1 not eaten was killed
6	,, 27	,, 28	4	2	
2	,, 28	Mar. 1	2	0	
0	Mar. 1	,, 2	0	0	
8	,, 2	,, 3	5	3	
6	,, 3	,, 4	3	3	
8	,, 5	,, 6	4	4	
8	,, 6	,, 7	8	0	
8	,, 8	,, 9	5	3	
11	,, 10	,, 11	5	6	
12	,, 12	,, 13	9	3	
8	,, 16	,, 17	4	4	
5	,, 19	,, 20	2	3	1 cricket died Mar. 17.
5	,, 21	,, 22	2	3	
5	,, 24	,, 25	3	2	
4	,, 27	,, 28	3	1	
5	April 1	April 2	3	2	
5	,, 5	,, 6	2	3	
5	,, 12	,, 13	4	1	
5	,, 17	,, 18	0	0	Cricket died April 18.

Total for 2 crickets 123 72
Number of days larvæ were supplied .. 66
Average No. of larvæ eaten per day by each cricket .. , 92

TABLE 7.

The Influence of *Liogryllus bimaculatus* on Codling Larvæ in Bands.

Tree No.	Date Collected.	Codling Larvæ Collected	Crickets Collected.	Reduviids Collected.	Tree No.	Codling Larvæ Collected.	Crickets Collected.	Reduviids Collected.
7	Jan. 2	1	0	2	8	0	0	0
9	,, 2	1	0	0	9	2	0	2
8	,, 2	1	0	2	10	0	0	2
7	,, 8	0	0	0	8	0	0	2
8	,, 8	0	0	0	9	0	0	1
9	,, 8	1	0	2	10	0	0	1
7	,, 18	0	0	0	8	3	0	4
8	,, 18	1	0	2	9	1	0	2
9	,, 18	1	0	4	10	0	0	0
7	,, 23	0	1	0	8	1	0	1
8	,, 23	0	0	2	9	0	1	2
9	,, 23	2	1	2	10	0	0	2
7	,, 29	1	2	0	8	2	0	3
8	,, 29	2	1	0	9	3	2	1
9	,, 29	0	1	2	10	3	4	1
7	Feb. 2	0	0	0	8	5	0	2
8	,, 2	0	2	2	9	5	0	2
9	,, 2	0	0	2	10	3	0	2
7	,, 8	1	3	0	8	14	2	0
8	,, 8	3	0	0	9	12	1	2
9	,, 8	3	4	0	10	6	2	0
7	,, 14	4	2	0				
8	,, 14	3	1	2				
9	,, 14	5	3	0				
7	,, 24	0	3	0				
8	,, 24	4	2	0				
9	,, 24	2	0	2				
7	,, 19	5	0	1				
8	,, 19	5	0	0				
9	,, 19	3	0	0				
		Total.				Total.		
7		12	11	3	8	25	2	12
8		19	6	8	9	23	4	10
9		18	9	16	10	12	6	8

TABLE 8.

Record of Six Adult Reduviids, confined with Codling Larvæ, February 9.

CODLING LARVÆ.				
Number of Larvæ.	Supplied to Bugs.	Date of Examination.	No. eaten by Bugs.	No. not eaten by Bugs.
7	Feb. 9	Feb. 12	5	2
7	,, 12	,, 13	2	5
7	,, 13	,, 14	0	7
7	,, 14	,, 15	1	6
7	,, 15	,, 16	1	6
7	,, 16	,, 17	1	6
7	,, 17	,, 18	2	5
7	,, 18	,, 19	1	6
7	,, 19	,, 20	3	4
7	,, 20	,, 21	4	3
7	,, 21	,, 22	6	1
7	,, 22	,, 23	3	4
7	,, 23	,, 24	2	5
7	,, 24	,, 25	3	4
5	,, 25	,, 26	1	4
5	,, 26	,, 27	1	4
5	,, 27	,, 28	3	2
2	,, 28	Mar. 1	0	2
2	Mar. 1	,, 2	0	2
5	,, 2	,, 3	1	4
5	,, 3	,, 4	3	2
8	,, 5	,, 5	3	5
5	,, 6	,, 8	0	5
5	,, 8	,, 10	1	4
5	,, 10	,, 12	2	3
5	,, 16	,, 19	1	4
5	,, 19	,, 24	2	3
5	,, 27	April 1	1	4
5	April 1	,, 5	2	3
5	,, 5	,, 11	1	4
5	,, 11	,, 17	1	4

A NEW APPLE TREE CANKER.

By V. A. Putterill, M.A., Division of Botany, Pretoria.

With 6 Text Figures and Plates XXI-XXX.

Read July 11, 1919.

In February of this year a parcel of diseased apple tree branches was received at the Phytopathological Laboratories from the Vereeniging Estates, Ltd. Mr. Brandmuller, the manager of the Estates, wrote of them as follows:—

> "The disease frequently occurs in our old apple orchards, but I have not yet noticed it in our younger orchards, in which the trees are from two to ten years old. All varieties of apples planted here are subject to it, but chiefly White Winter Pearmain. The trees are sprayed regularly with fungicide, in earlier years with Bordeaux mixture, in latter years with commercial lime-sulphur. All diseased branches are cut out and burned. I shall be glad if you can recommend me any other measures of control, as the disease appears to get more troublesome every year."

In a later letter the manager writes:—

> "I made an inspection and found 58 trees out of 2,500 trees in our older orchard affected, which I had burned before taking them out."

In June I paid a visit to the Vereeniging Estates to see the extent of the disease in the orchards. The disease has been giving trouble in the oldest orchard of 2,500 trees; 58 of these had already been burned, but a number showing the disease still remained. The majority of these were the Yellow Bell Flower variety on non-blight proof stock, some 20 years old, which had been cut down and worked over to Versfeld, White Winter Pearmain, Cellini, and Rome Beauty, etc., about nine years before. The disease was especially bad on the Yellow Flower part of the trees, in many cases confined to it, often almost completely girdling the six-inch diameter trunk; whereas the tops looked particularly healthy, though cankers were present on some of the younger limbs. (See plates XXI, XXII, and XXVII (*b*).)

Mr. Brandmuller states that the disease first came to his notice, as something which might possibly be harmful, about two years ago, through the dying of branches when the trees were in leaf. Prior to this, he is of opinion that possibly the disease was overlooked owing to its being confused with sun scorch. The control measures he has used consist largely in cutting out diseased branches and cankers, and painting over the wound,

Cankerous Apple Trees.

V. A. Putterill.—A New Apple Tree Canker.

Cankerous Apple Trees.

besides spraying the trees regularly as a preventive with lime-sulphur. Possibly one reason why the disease has made headway in the orchard, notwithstanding the pains taken to control it, is that the fungus is present in the outer layers of the wood; failure to cut this diseased wood out when removing the canker would, of course, seriously detract from the value of the operation. I think, too, that woolly Aphis has been instrumental in spreading the disease.

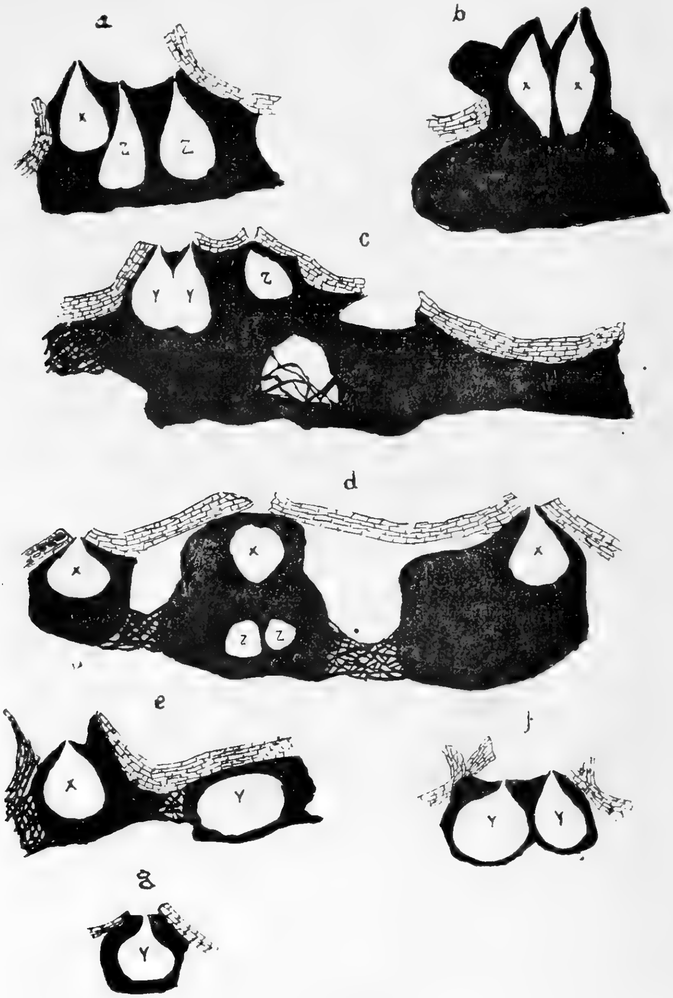
As far as rot of the fruit is concerned, Mr. Brandmuller has not noticed any difference between the fruit from diseased trees and fruit from healthy ones.

Examination of one of the branches (Versfeld) showed the presence of numerous pycnidia, these being visible externally as minute black spots. Cultures were plated out from the spores, which were present in abundance, and at the same time the germinating power of the spores was tested. It was found that they germinated readily in nutrient solutions and in distilled water. The fungus was found to grow readily on nutrient media, so that the isolation of pure cultures was easily effected. Inoculations of the mycelium into two young Northern Spy stocks caused the development of black sunken cankers on both, while the wound made in a control tree similarly treated, except for the introduction of fungous mycelium, healed perfectly well. A characteristic of the cultures was the evident unwillingness of the fungus to form spores or fruiting bodies. I shall return to this point later on. Owing to this, and also to press of work, the investigation was laid aside for about two months, when I again made an examination of the original material. Sections of pieces of the bark which had been fixed in boiling 10 per cent. formalin and cut on a freezing microtome showed that amongst the pycnidia there were bodies of similar shape but containing what appeared in some cases to be immature asci, in others a compact mass of delicate interwoven hyphæ. Pieces of the bark were then placed in a moist chamber and examined after 24 and 48 hours. It was found that, firstly, the pycnidia exuded out from the stromata, and could be seen as whitish specks on the surface, and, secondly, that the supposition of the presence of an ascus stage was correct, asci containing ascospores being fairly frequent. Plate XXVII (*b*) shows a portion of a cankered limb of Versfeld apple; the view on the left of the photograph shows the discoloration of the wood due to the growth of the fungus.

Description and Systematic Position of the Fungus.

Hesler (1), who proved the perfect stage of *Sphæropsis malorum* Berk to be *Physalospora cydoniæ,* notes that there is some variability as regards the colour of the pycnospores in this fungus, which ranges from dark to hyaline; the latter may frequently be quite capable of germination, in which case he considers them to be prematurely ripe. He also notes that the

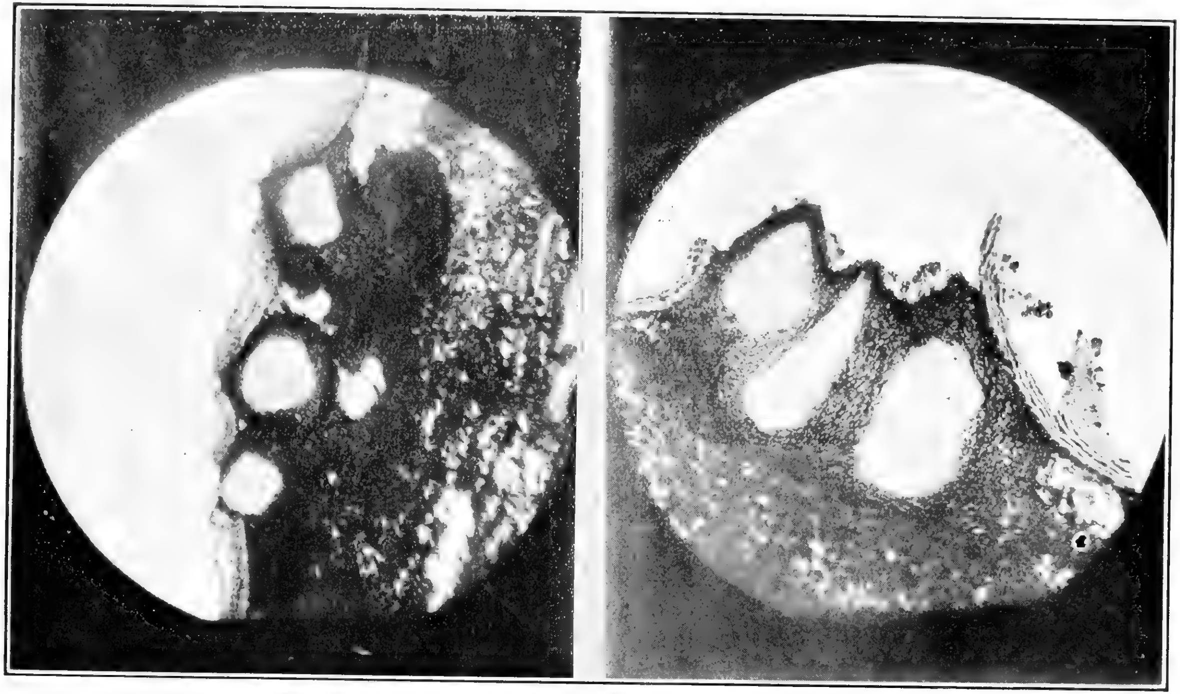
pycnidia may sometimes be grouped together in a stroma. As regards the ascus stage, the persistent absence of a stroma, *inter alia,* places the fungus in the genus *Physalospora,* which is characterised for one thing by being non-stromatic, and having continuous hyaline ascospores. He admits, however, the possibility of the occurrence of perithecia in stromata, although he has never



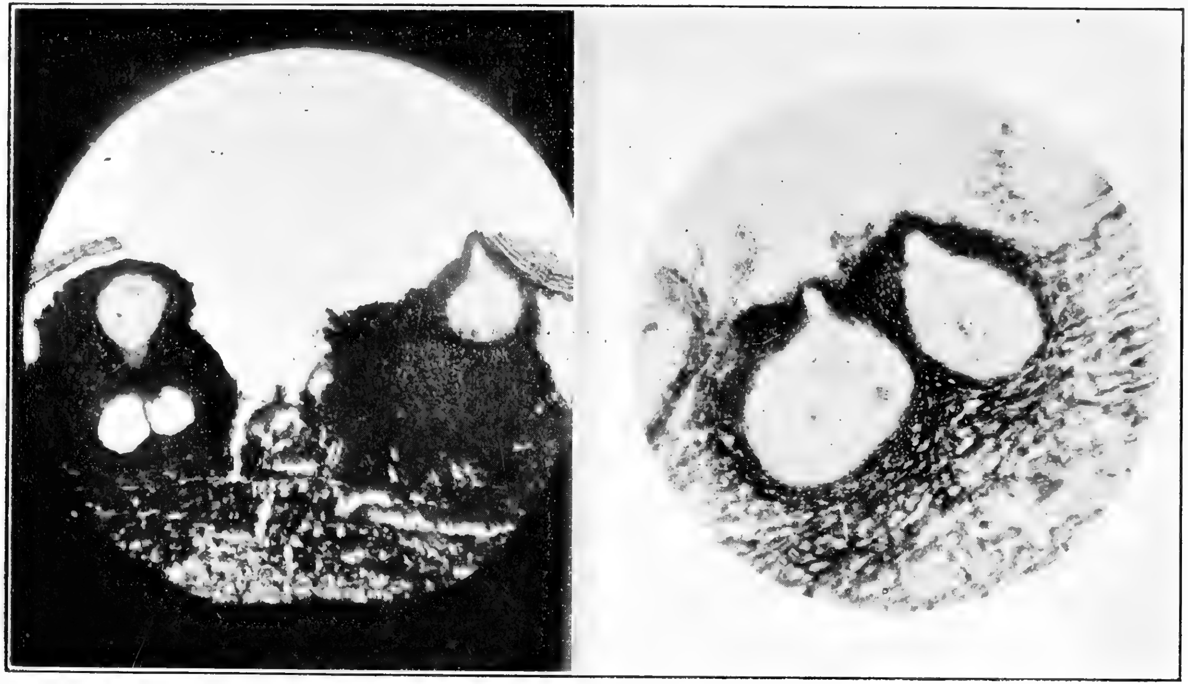
Text fig. 1.

come across them in his investigations, in which case *Physalospora cydoniæ* would have to be put into the genus *Botryosphæria.*

These facts, for a time, made me wonder whether the fungus I was examining was not, perhaps, a variety of *Physalospora*



Sections through Stromata of Fungus of Apple Trees.



(a) Sections through Stromata of Fungus of Apple Trees. (b)

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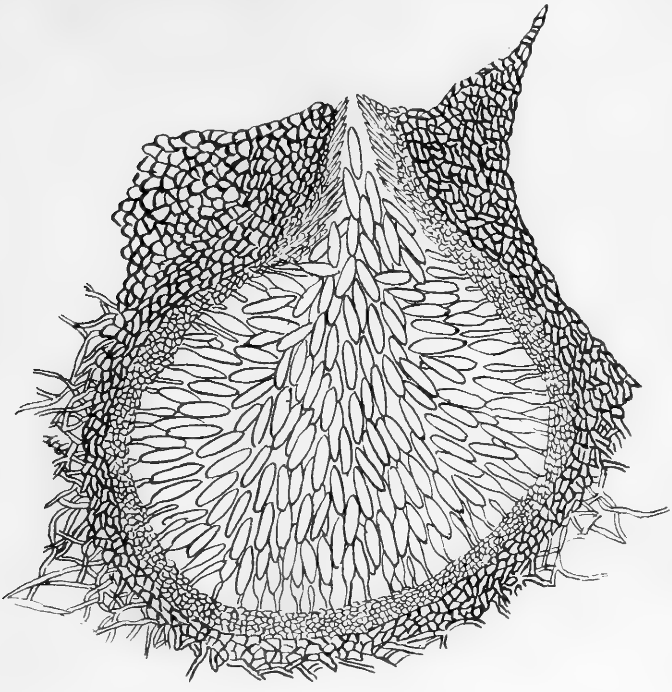
cydoniæ as described by Hesler. However, the total absence of anything but hyaline pycnospores, the difference in spore dimensions, presence of stromatic perithecia, and other points were sufficient to show that this could not be.

DESCRIPTION.—Stroma usually pulvinate, sometimes more or less effused, seldom absent; black, frequently about ½ mm. wide; erumpent. Perithecia somewhat top-shaped, either completely sunken in or partially imbedded in the stroma; neck, when present, not long; paraphyses and ostiolar filaments present, about 235μ long by 149μ wide as a rule. Asci clavate, $96\mu \times 13\mu$ con-



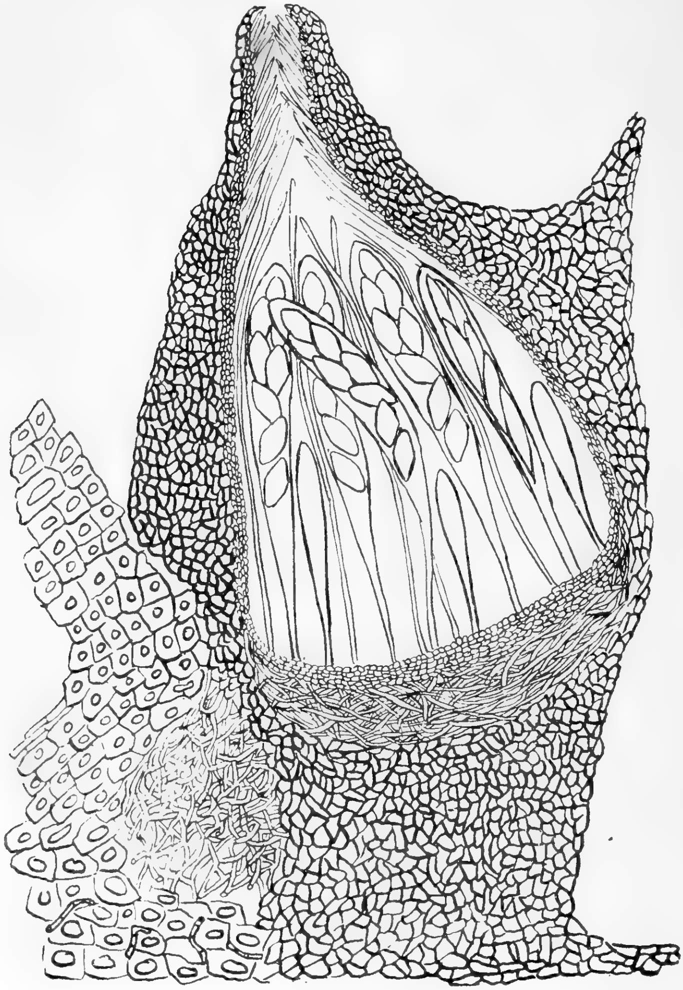
Text fig. 2.

taining 8 ascospores, uniseriate below, and becoming tri-seriate above. Ascospores fusiform, continuous hyaline, 19.2-$19.5\mu \times 6.5$-8μ.

Pycnidia top-shaped, usually grouped on a stroma, averaging $250\mu \times 190\mu$. Ostiolar filaments present but no paraphyses. Pycnospores hyaline cylindric, non-guttulate, continuous $22.4\mu \times 4.8\mu$.

The stromata are formed of pseudo-tissue of a dark brown colour. Text fig. 1, *a-g*, shows some typical stromata, with the reproductive bodies immersed in them; *x*, denoting a perithecium; *y*, a pycnidium; and *z*, an empty body, either perithecial or pycnidial. The stromata are as a rule pulvinate; 1 *c* shows

a case where the stroma tends to be effused; while in 1 *g* it is almost a question whether a stroma is not absent altogether, the pycnidium then being of *Macrophoma* type, with an outer dark wall and an inner hyaline one. If this view be correct, then the outer wall in the case of the stromate pycnidia is present, though scarcely distinguishable from the inner layers of the stroma.



Text fig. 3.

It seems to me, however, more probable, considering the thickness of the outer layer, that in 1 *g* the pycnidium is solitary but stromatic. The pycnidia vary somewhat in shape; 1 *c* shows a case where the dividing wall between two pycnidia is absent, though ostioles are distinct. Text fig. 2, which is a high-power

drawing of one of the pycnidia in 1 *f*, is typical. Text Figure 3 is a high-power drawing of the perithecium in 1 *a*, showing mature asci, one ascus in which the ascospores are not yet quite mature, several young ascus tubes, paraphyses and ostiolar filaments. The lowest two ascospores are uniseriately arranged in the ascus; a cross section of the ascus towards the distal end, however, usually shows three spores in section. The spores are liberated by gelatinization of the ascus walls; as gelatinization takes place, the spores which are grouped towards the end of the ascus become arranged uniseriately.

Text fig. 4.

Germination of both types of spore takes place readily in nutrient solutions and in distilled water. The pycnospores frequently become septate, and an outer wall becomes visible (Text fig. 3). Text fig. 4, *a-g*, shows germinating pycnospores, 4 *h* a germinating ascospore.

Plates XXIII, XXIV give photomicrographs of stromata, pycnidia and perithecia (XXIII, XXIV *a*, perithecia; XXIV *b*, pycnidia).

Systematic Position of the Fungus: The above characters place the fungus as belonging to the genus *Botryosphæria*, the second genus of the *Melogrammataceæ*, which, in turn, is one

of the families of the Sphæriales, characterised by having stromate perithecia and rather large ascospores. The pycnidial stage belongs to the genus Dothiorella, and, in some cases, when not stromatic, possibly to the genus Macrophoma.

This fungus has many points in common with *B. ribis*, described by Grossenbacher and Duggar (2). The chief difference lies in the greater width of the ascus, which in *B. ribis* is 17-20μ. Also the stromata are, as a rule, larger in diameter, this ranging from 0.5 mm. to 4 mm., 2 mm. being most usual.

It has affinities also with *Botryosphæria pruni*, described by McAlpine (3), and occurring on dead apricot and plum twigs. This fungus differs, however, in having wider perithecia (300-400μ), and the ascospores being slightly larger (20-24 x 8-9μ), and having finely granular contents.

The characters of *Dothiorella mali*, E. and E. (4) on dead branches of *Pirus malis* seem to agree in some particulars with the Dothiorella stage of the fungus under discussion; the pycnospores of the latter are slightly longer, the stromata not so large, and the spores not granular.

As this fungus seems to be a species hitherto undescribed, I propose the name *Botryosphæria mali*, n.sp., for it.

Cultural Characters.

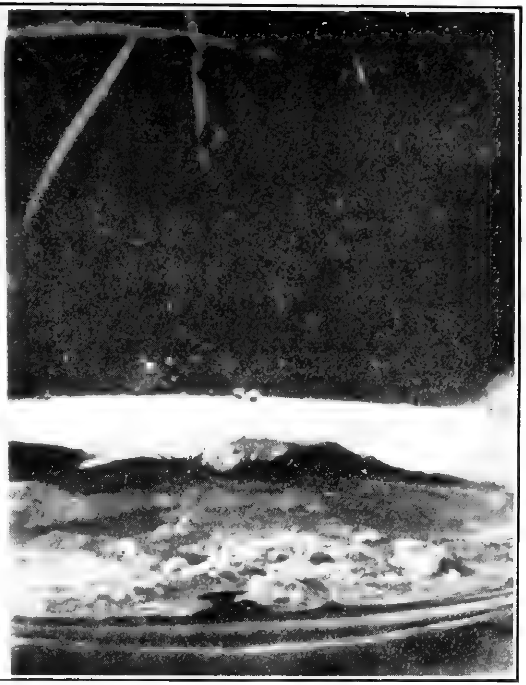
Cultures from the pycnospores on most nutrient agar-agar media are at first pure white, the mycelial growth being cottony. The colour gradually darkens from the centre outwards, through grey to greenish black, or almost black.

This holds for the following media: Prune agar, malt extract (5), oatmeal agar, Wittes' Peptone (6) medium, Coons' nutrient solution (7), and also for vegetable media such as rice tubes, potato cylinders, bean stems, apple twigs and apple chips. The production of the dark colour seems to be more or less inhibited in modified Uschinsky's solution (8), the only evidence of darkening being a slight greyish tint in the aerial mycelium. Growth in beef broth agar is peculiar and characteristic. Active growth seems to stop when the colony reaches about two inches in diameter; the mycelium is sub-felty and white; the submerged mycelium at the periphery forming a band or border about one millimetre wide turns black (Plates XXV, XXVI) in the case of cultures incubated in the dark, and remains colourless in the case of cultures in light (XXV*a.*). *Chromogenesis* as observed by Grossenbacher and Duggar (9) for *Botryosphæria ribis* growing on starch paste was obtained when this fungus was grown on starch paste — 5, and — 10, in the lights the colour being Madder Brown (10).

The production of this colour, however, was apparent for only a very short while, disappearing as the cultures got older.

Light has an important action in the darkening of the mycelium; although not always essential for the development of

(a) Fungus Culture on Beef Broth in Light.



(b) Fungus on Coons' Solution.

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(*a*) Fungus on Coons' Solution.

(*b*) Fungus Culture on Beef Broth in Dark.

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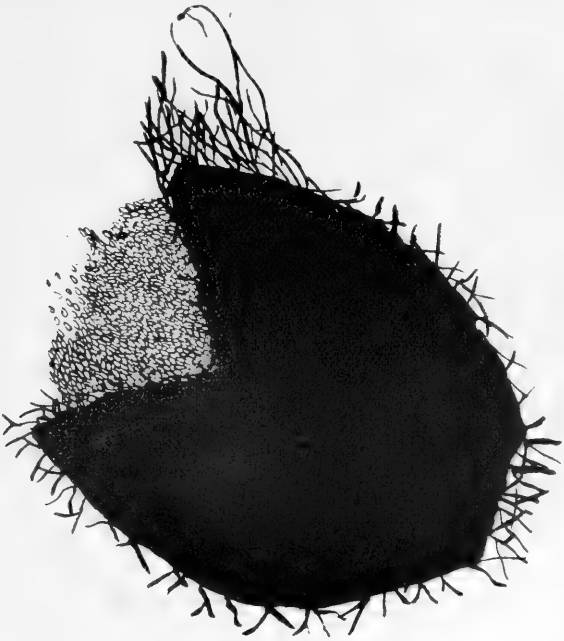
the colouration, it intensifies it and stimulates its production. On some media, such as apple wood chips, it seems to be necessary.

Light, moreover, seems to be essential for the development of fruiting bodies, thus agreeing with Coons' (7) observations in connection with *Plenodomus fuscomaculans*. This fact accounts for failure at first to obtain spores in culture: however, when comparative cultures were made (*see table*), one series being kept in the dark and the other in the light, the cause of the sterility of the fungus was found to lie in the absence of photic stimulus.

Fruiting bodies in the form of pycnidia, of Macrophoma type, were first observed in cultures on Coons' solution which



Text fig. 5.

had been growing in the light. They were visible to the naked eye as small bodies on the surface of the hyphal weft (Text Fig. 5), the actual dimensions being 600 x 530μ. The spores (21 x 5μ) germinated readily in distilled water and in nutrient solution.

Besides the above pycnidia, bodies of a sclerotial or stromatic nature were formed on various media in the light, potato cylinders, rice and apple chips, being especially suitable; formation of these bodies also takes place on Coons' solution and most other media in the light. Drops of water exude from the surface. (Plates XXV*b*, XXVI*b*, XXX*b*, also Text fig. 6.)

Cultures in Coons' solution two months old showed numerous black excrescences on these stromatic bodies, which on examination proved to be pycnidia. (Text fig. 5, Plate XXX*a*.)

Text fig. 6.

Inoculation Experiments.—On the 4th of March two Northern Spy Stocks were inoculated with mycelium from one of

the pure cultures grown from the pycnospores. The inoculum was introduced into a wound in the stem made with a sterilised scalpel, and the wound covered with moist filter paper. By the 12th of the month black areas surrounding the wounds were clearly visible. As controls, a similar wound was made in one, but no mycelium introduced, and in another, mycelium of a fungus which had also been isolated was introduced, both being covered with moist filter paper. In both of the controls the wounds healed up. (Plate XXVII *a, c.*)

By June the black areas in one had developed into a sunken canker, 1½ cm. wide by 6 cm. long, this being cut off from the healthy tissue by a brown corky fissure. A number of smaller pustular bodies were present on the surface which had not yet ruptured the outer layers of the periderm; these on sectioning proved to be stromata, containing what appeared to be immature fruiting bodies. The wood was discoloured under the cankered area for about a distance of 4 mm. (Plate XXVII *c.*) The colour was a yellowish-brown, which after several days turned almost black. This possibly accounts for the blackening of the wood in many of the trees in the orchard after the cankered bark had been removed. In a young canker about three weeks old, which was obtained by inoculating a twig about ½ cm. in diameter, the blackened dead tissue was surrounded by a narrow water-soaked zone, about 1 mm. wide, this grading externally into healthy tissue. A section of the wood, stained in Delafield's hæmatoxylin and eosin according to the method of Durand (12), showed a delicate mycelium in the outer layers. Discoloration of the wood extended, after about seven months, some three to four inches up the stem in the case of one of the inoculated apple stocks. (Plate XXVIII*a.*)

The fungus was re-isolated from the larger canker as follows:—A fine shaving was cut off with a sterilised razor from a piece of the blackened bark, just removing the outer periderm; the razor was sterilised again and pieces of tissue containing the stromata cut out and inserted into prune agar slant tubes and incubated at 31° C. After about 48 hours typical white cottony growth was apparent in each. Not every one of the later inoculations with the original strain took effect. It may be that the pathogenic power of the fungus wanes when grown for any length of time on artificial media; or possibly the incisions made in the bark were allowed to dry out too rapidly; or perhaps the resisting powers of the tree may differ at different times of the year.

Inoculation of fruits.—Inoculations of sound fruits by making an incision into the skin with sterilised scalpel and inserting by means of platinum loop a suspension of spores obtained from pure culture resulted, after about 10 days, in a yellow sunken area. Later concentric zones of black fruiting bodies were formed. (Plate XXVIII*b.*)

TABLE GIVING CULTURAL CHARACTERS

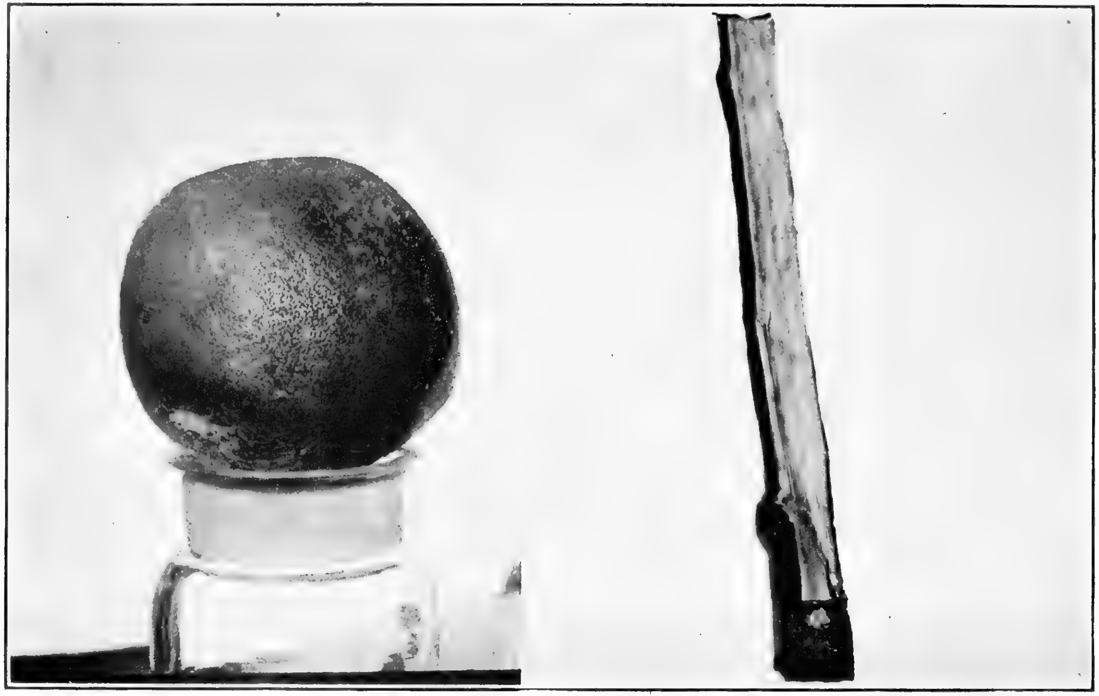
GROWN ON VARIOUS MEDIA

MEDIA INOCULATED

* Those marked with an asterisk

Simular results obtained when the fungus was either incu-

Inoc. 23.5.19 Retransf. 27.5.19 Medium.	June 4, 1919.		June 9, 1919.	
	In Room in Light.	Inc. 31° C.	In Room.	Inc. 31° C.
Beef Broth Agar.*	$1\frac{3}{4}''$ diam. Mycelium slightly greyish ; zoned.	$2''$ diam. Snow-white cotton mycelium ; fairly compact growth.	As before.	As before.
Malt Extract Agar.*	Mycelium over whole surface of plate; cottony; grey : zoned.	Cottony white mycelium covering surface. Tendency to be zoned ; very slight greenish tint at point of inoculation.	Almost uniformly grey.	Zoned ; mycelium grey in rings and patches.
Bean Agar.*	Vigorous mycelium ; marked zonation ; aerial mycelium of raised zones white ; when viewed through the medium general colour grey green.	White mycelium ; not zoned ; even growth over whole surface.	Zoned; light grey.	Slightly grey, especially towards centre.
Prune Agar.*	Mycelium over almost whole surface of plate ; growth not thick grey green ; distinct zonation.	White mycelium, zoned ; almost black and somewhat sodden at point of inoculation.	As before.	Mycelium with slight greyish tint.
Potato Tube.	Greenish mycelium, black in places Small mycelial mounds developing.	Dark green cottony mycelium ; at tip of potato cylinder mycelium white.	Mycelium mounds which exude drops of water	Uniformly dark.
Rice Tube.	Mycelium greenish black ; large mounds on surface.	Greenish cottony growth.	Mounds very large.	As before.
Bean Stem.	Mycelium light grey in places and elsewhere dark green, submerged mycelium white. Mycelial mound about water level.	Mycelium greenish white in places. Submerged mycelium white.	Drops of water exuding from mycelial mound	As before.
Apple Twig.	Mycelium green; submerged mycelium white	Mycelium white.	Mycelial mounds.	As before.
Apple Chips	Mycelium forming dirty green mat over whole surface.	Mycelium white zoned.	Some large mycelial mounds with drop of water.	As before.
Coon's Solution.	Film on surface greyish white ; submerged mycelium green.	Deeply submerged mycelium white ; mycelium at surface mixed	Mycelium grey black Mycelial	As before.



(*a*) Inoculated Northern Spy. (*b*) Inoculated Apple showing Pycnidia.

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(*a*) Inoculated Northern Spy.

(*b*) Discoloration and Canker.

(*c*) Inoculated Northern Spy.

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FOR *BOTRYOSPHÆRIA MALI.*
IN LIGHT AND IN DARKNESS.

MAY 23, 1919.
inoculated May 27th, 1919.
bated at 25° C. or kept in darkness without incubation.

June 18, 1919.		July 11, 1919.	
In Room.	Inc. 31° C.	In Room.	Inc. 31° C.
Mycelium as before; 2″ diam. Peripheral ⅛″ submerged.	White subfelty mycelium. Peripheral 1 mm. submerged black.	Submerged edge lobate; otherwise as before. Plate III, *a*.	As before. Plate III, *b*.
As before.	As before.	As before; no bodies visible.	Light and dark alternating zones.
Mycelium darker than before	White mycelium slightly grey in places, darker at centre.	As before; bodies (mounds)?	As before.
Dark grey; subfelty; bodies not definite.	As before.	Two sclerotial bodies with drops exuding, central 2″ of growth appressed.	White in places. No bodies.
As before	As before.	As before.	As before. No bodies.
As before.	As before	As before.	Two mounds mycelial tufts.
As before.	As before.	As before.	Culture dried out. No bodies.
Mycelium black and sodden in places. Pycnidia ?	Mycelium grey.	Two particularly large bodies with drops and others without.	Mycelium white in places, elsewhere dark, dried out. No bodies.
As before.	As before.	Numerous club-shaped mounds with drops exuding (about ¾ cm high).	White; slight greyish tint.
As before.	As before.	Large bodies with drops of exudation.	As before.

Inoculation of Leaves.—A shoot was atomized with a suspension of spores obtained in pure culture, and kept under moist conditions in the greenhouse for about 48 hours. No effects were visible after two weeks.

Summary.

In this paper a fungus belonging to the genus *Botryosphæria* is described, which is the cause of a rather serious canker of apple trees at the Vereeniging Estates.

An account is given of its morphology and its salient cultural characters, and of a number of inoculation experiments which were carried out with the fungus at the laboratories.

The differences between the fungus under discussion and *Phyalospora cydoniæ*, the cause of New York apple tree canker, are noted. The fungus shows some affinities with several other species of the genus, but is sufficiently different to be considered a new species. Accordingly, the name of *B. mali* has been assigned to this fungus.

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(7) Coons, G. H.—" Factors Involved in the Growth and the Pycnidium Formation of *Plenodomus fuscomaculans*." —Journal of Agricultural Research, Vol. V., p. 713.

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(9) Grossenbacher and Duggar—*loc. cit.*

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(11) Coons, *loc. cit.*, p. 720.

(12) Durand.—" The Differential Staining of Intercellular Mycelium." Phytopathology, Vol. I (1911), p. 129.

(*a*) Sporophores of *Schizophyllum commune.* (*b*) Stroma of *B. mali* on Apple Twig.

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(*a*) Pycnidia on stroma. (*b*) Stromata on Apple Wood Chips.

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DESCRIPTION OF PLATES XXI to XXX.

PLATES XXI, XXII.

Photographs taken at Vereeniging showing diseased trees and limbs.

PLATES XXIII, XXIV.

Photomicrographs of sections through stromata of the fungus.

PLATE XXV.

(*a*) Culture of fungus on beef broth agar in light.
(*b*) Fungus on Coons' Solution showing mycelial bodies.

PLATE XXVI.

(*a*) Fungus on Coons' Solution, showing mycelial bodies.
(*b*) Culture on beef broth agar in dark.

PLATE XXVII.

(*a*) Inoculated Northern Spy Stock.
(*b*) Portion of cankered limb of apple. The view on the left shows discoloration of wood due to growth of fungus.
(*c*) Inoculated Northern Spy Stock, showing discoloration of outer layers of the wood.

PLATE XXVIII

(*a*) Inoculated Northern Spy Stock, showing discoloration of internal tissues three months later.
(*b*) Inoculated apple showing pycnidia.

PLATE XXIX.

(*a*) Dead bark of a canker showing sporophores of *Schizophyllum commune* as saprophyte.
(*b*) Stroma of *Botryosphæria mali* on apple twig from culture tube after three months.

PLATE XXX.

(*a*) Pycnidia on stroma in Coons' Solution.
(*b*) Stromata on apple wood chips.

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SOUTH AFRICAN METEOROLOGY: TYPES OF ATMOSPHERIC PRESSURE, THEIR DURATION AND MOVEMENTS.

By A. G. Howard, M.S.A. Lond.

With Text Figures.

Read July 10, 1919.

The main atmospheric pressure condition affecting the weather of South Africa is the anticyclone, which encircles the earth between the tropical and temperate zones; this belt is at its maximum over the oceans and at its minimum over the continents. That portion over the South Atlantic Ocean is constantly fluctuating in intensity, increasing towards the west, forming a high pressure there, which, moving eastwards, breaks off and rolls past the south coast in summer and across the land in winter. Between any two high pressures one would expect to find a V-shaped low pressure area to the north, and an inverted

one to the south, and such is the case, although upon many occasions the high pressures follow one another so closely that these areas of low pressure are of little importance, as they do not develop into veritable lows.

At about 60° of south latitude true cyclones are constantly moving from west to east, and as these pass along, their northern fringes affect South Africa, surges keep on rolling northward, and expend their forces against the anticyclone belt. When, however, they approach the west coast, where the Atlantic high has its minimum width, they extend much further north and often join issue with the low, which comes down from the equatorial region as a V-shaped depression. If there be a high pressure over South Africa, or even if one be moving away eastwards, the low area, a long inverted V, extending in a south-westerly to north-easterly direction, sweeps right across the sub-continent, but, owing to the presence of the equatorial low pressure, known as the monsoonal tongue, it swings round, so that when it is on the south coast it extends from south to north, while as it passes away to the east, its axis becomes south-easterly to north-westerly. This sequence is most common during summer.

During winter there is usually a more or less permanent high pressure over the north-east (Transvaal and east), and this often extends to the west coast, the whole forming a belt of high pressure with two cores which fluctuate in intensity. Should a trough of low pressure approach from the west and the high be over the north-east only, the low will extend along the west coast, being first noticed well to the north, moving down to the south-west. The high, however, will remain firm, and the arm of the low will be slowly withdrawn, the appearance being that of a low moving down the west coast, and along the south to the south-east or east ocean. The high will be but little affected, except that it may be reduced in intensity owing to its having supplied atmosphere to the low in passing.

In Europe each pressure type is named after the prevailing winds, but in South Africa winds are affected by local conditions to such an extent that it would not be safe to base any groupings on them. It has, therefore, been deemed more satisfactory to define the types according to the positions of the high pressures. By doing this we get six clear types.

1. *The Westerly (W) Type.*—High over the west coast, sometimes extending to the south. Prevailing winds should be southerly to westerly.

2. *The Easterly (E) Type.*—High over the north-east (Transvaal and east), sometimes extending to the southern coast. Prevailing winds should be northerly.

3. *The Southerly (S) Type.*—High over south or south-east or both. Prevailing winds should be easterly, but the presence of the warm sea current often induces westerly winds.

4. *The Central (C) Type.*—High over the whole of the sub-continent, but often lower over the centre, causing the appearance of two highs and a slight V. Prevailing winds should be westerly on coast but various over the interior.

5. *The All-Low (L) Type.*—Low over the whole of South Africa, no decided high anywhere. Prevailing winds must be decided by the positions of the areas where pressure is least; if on the west coast, they should be easterly; if on the south coast, they should be south-west to easterly; and if in the east, they should be southerly to westerly.

6. *The Pericyclonic (P) Type.*—High over west and along southern coast to north-east or east; sometimes the west element is missing or the south or south-east one. Prevailing winds should be southerly through easterly to northerly.

The definition of a high and a low is as follows: A Low is an area of low pressure bounded by the 29.90 inches isobar; an average High has readings of the barometer more than 29.90 inches, and less than 30.10 inches, and a true High is an area of high pressure bounded by the 30.10 inches isobar.

In the following diagrams giving rainfalls following various pressure types, the districts are defined thus: W, west Cape; SW, south-west Cape; C, central Cape; S, south Cape; SE, south-east Cape; N, Natal; FS, Free State; WT, west Transvaal; CT, central Transvaal; ET, east Transvaal.

Diagrams indicating where Rain fell during the 24 hours governed by a Pressure Type.

Summer Types.

Where cloudy, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	X	X	X	X	X	X	X	X
E Type	—	—	X	X	X	X	X	X	X	X
S Type	—	—	X	X	X	X	X	X	X	X
C Type	—	—	X	X	X	X	X	X	X	X
P Type	—	—	X	—	X	X	X	X	X	X
L Type										

Where cloudy, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	X	X	X	X	X	X	X
E Type	—	X	—	X	X	X	X	X	X	X
S Type	—	—	—	X	X	X	X	X	X	X
C Type	—	X	—	X	X	—	X	—	X	X
P Type	—	—	—	—	X	X	X	X	X	X
L Type	—	X	—	X	X	X	X	X	X	X

Where fine, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	X	X	—	X	—	X	X
E Type	No rain.									
S Type	—	—	—	—	—	—	X	—	X	X
C Type	—	—	—	X	X	—	X	—	X	X
P Type	—	—	—	—	—	X	X	X	X	X
L Type	—									

Where fine, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	X	X	—	X	—	—	X
E Type	—	—	X	—	X	X	X	—	—	—
S Type	—	—	—	—	X	X	X	—	X	X
C Type	—	—	—	X	X	X	X	—	—	—
P Type	—	—	—	—	X	X	X	X	—	X
L Type	—	—	—	X	X	X	X	X	—	X

Autumn and Spring Types.

Where cloudy, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	X	—	X	X	X	X	—	X	X
E Type	X	—	X	—	X	X	X	X	X	X
S Type	—	—	—	—	X	—	X	X	X	X
C Type	—	X	X	—	X	X	X	X	X	—
P Type	—	—	—	—	—	—	X	—	—	X

Where cloudy, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	X	—	—	—	—	—	X
E Type	X	X	X	—	X	X	X	X	X	X
S Type	—	—	—	—	—	—	X	—	X	X
C Type	—	X	X	X	X	X	X	X	X	—
P Type	—	X	—	X	X	X	X	—	—	X

Where fine, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	X	—	X	X	—	X	—	X	X
E Type	X	—	X	—	X	X	X	X	X	X
S Type	—	—	—	—	X	—	X	X	X	X
C Type	—	X	X	—	X	X	X	X	X	—
P Type	—	—	—	—	—	—	X	—	—	X

Where fine, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	—	X	—	X	—	—	X
E Type	—	X	—	X	—	—	—	—	—	—
S Type	—	—	—	X	X	X	X	—	X	X
C Type	—	X	—	X	X	—	X	—	—	—
P Type	—	X	X	—	X	—	—	X	X	X

Winter Types.

Where cloudy, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	X	—	X	X	—	X	X	X	X
E Type	X	X	X	X	—	—	X	X	—	—
S Type	—	—	—	—	X	X	X	—	X	X
C Type	—	X	X	X	X	—	X	X	X	X
P Type	—	X	—	X	X	X	X	X	—	—

Where cloudy, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	X	—	X	X	X	—	—	—	—
E Type	X	X	X	X	X	X	X	X	—	—
P Type	No Lows.									
C Type	X	X	X	X	X	X	X	—	—	—
S Type	No Lows.									

Where fine, no Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	X	—	X	—	—	X	—	X	—
E Type	No rain.									
S Type	No rain.									
C Type	No rain.									
P Type	No rain.									

Where fine, with Lows.

	W	SW	C	S	SE	FS	N	WT	CT	ET
W Type	—	—	—	X	—	—	—	—	—	—
E Type	X	X	—	X	—	—	—	—	—	—
S Type	No Lows.									
C Type	—	X	—	X	X	—	—	—	—	—
P Type	No Lows.									

Duration and Movement of High and Low Pressures.

The point now to be decided is, how long will a High remain in approximately the same position, and where will it most probably move to? The results of investigating the periods when Highs and Lows remained stationary, when they moved, and where to, are embodied in the following tables:—

Lows.—Summer.

	Duration.						Movement.					
Type.	Days when Low.	Duration Days. 1	2	3	More.	Days when Low.	Where moved to. W	E	S	P	O	L
W	190	80	72	30	8	127	—	5	79	12	17	14
E	106	79	16	9	4	89	25	—	13	7	42	2
S	298	129	130	15	24	202	14	55	—	15	107	11
P	58	40	18	—	0	49	11	8	23	—	4	3
O	389	135	68	57	129	169	73	5	75	3	—	2
L	52	19	22	3	8	33	4	14	10	14	19	—

Autumn and Spring.

W	33	22	4	3	4	27	—	0	22	0	5
E	10	8	2	0	0	9	0	—	1	0	8
S	95	48	38	9	0	70	5	8	—	2	55
P		None.						None.			
O	205	25	36	33	111	71	21	1	49	0	—

Winter.

W	34	25	6	3	0	29	—	0	19	0	10
E	3	3	0	0	0	3	0	—	0	0	3
S	127	47	36	21	23	77	3	3	—	0	71

No other Types.

Highs.—Summer.

Type.	Days when High.	Duration Days. 1	2	3	More.	Days when High.	Where moved to. W	E	S	C	P	O
W	224	85	64	45	30	138	—	12	91	20	8	7
E	224	85	72	27	40	137	19	—	29	70	8	11
S	329	110	122	38	59	184	21	90	—	46	16	11
C	202	120	62	12	8	157	68	21	41	—	23	4
P	62	52	10	0	0	57	10	16	14	16	—	1
O	52	18	22	12	0	32	19	3	8	1	1	—

Autumn and Spring.

W	42	21	6	3	0	30	—	8	11	4	1
E	132	21	38	24	49	57	6	—	5	44	2
S	47	25	18	4	0	35	0	22	—	13	0
C	109	40	40	21	8	69	24	20	10	—	15
P	22	16	6	0	0	19	1	6	1	11	—

Winter.

	Duration.						Movement.					
Type.	Days when High.	Duration Days. 1	2	3	More.	Days when High.	Where moved to. W	E	S	C	P	O
W	70	41	22	3	4	54	—	6	20	18	9	1
E	347	43	56	72	176	122	14	—	4	99	4	1
S	69	33	14	18	4	47	1	36	—	7	3	—
C	209	77	72	27	23	129	35	64	14	—	15	1
P	39	31	4	0	0	35	4	15	6	10	—	—

The following gives the number of days in each month when Lows or no Lows occur, based on calculations covering the six years 1913 to 1918, inclusive:—

	Low.	No Low.		Low.	No Low.
January	26	5	August	5	26
February	22	6	September ..	10	20
March	19	12	October	12	19
April	13	17	November ..	18	12
May	9	22	December ..	21	10
June	7	23	Year (mean) ..	14	16
July	6	25			
Summer (m) ..	19	11	Autumn and Spring (m)	12	18
Winter (m) ..	7	24			

It will be seen that Lows are more prevalent in summer than in winter, and this should be a guide in defining the duration of All High periods. Thus, take July: here the number of days when Lows were present is 6, and as Lows generally last one or two days, there will be 4 periods of Low, which, divided into 24, gives the mean number of days in each of the 4 periods when no Lows occur, in this case 6 days; and so with other months.

Advent of New Low Pressures.

It is also important to know where a new Low will appear after a spell of All High pressure. The following has been worked out from six years' observations:—

Position of High on last day of Period.	Where new Low will probably appear.
Summer.	
W Type	Look to S for new Low.
E „	Look to S.
S „	Look to W.
C „	Look to S.
P „	Look to S.
Autumn and Spring.	
W Type	Only one case.
E „	Look to S.
S „	Look to High being replaced by a Low.
C „	Look to S.
P „	Look to S High being replaced by a Low.
Winter.	
W Type	Only one case.
E „	Look to S.
S „	Look to W.
C „	Look to S.
P „	Look to W High being replaced by a Low.

Weather Accompanying Pressure Types.

Having now, approximately, arrived at the Type of Pressure which will follow an existing one, it will be possible, to a certain extent, to state what cloudy or fine weather should accompany such type. As the result of analyzing the various groups of Highs and Lows, the following table was prepared, giving the approximate percentages of cloud which should be found in each district upon the advent of one of the Pressure Types.

The second table gives a working basis for everyday use, based on the percentages. The symbols are: O, for 25 per cent. of cloud or less, being Fine Weather; S, for over 25 per cent. up to 50 per cent., representing cloud in places; and ● for 50 per cent. of cloud or more, being cloudy and unsettled weather.

Pressure Types; Percentages of Cloud which should be present over each District.

Summer, Highs without Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	4	3	7	19	57	19	75	19	35	57	68
E	3	5	6	14	21	13	31	16	26	35	62
S	2	1	4	8	42	22	69	29	52	72	170
C	6	16	8	20	34	14	20	22	28	26	48
P	5	5	5	5	28	15	38	30	33	43	40
											388

Summer, Highs without Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	18	26	6	20	42	20	55	23	36	39	155
E	18	19	19	14	24	27	30	26	35	36	170
S	9	6	3	19	45	21	62	32	50	61	162
C	21	38	17	12	19	17	21	24	28	25	152
P	6	19	0	0	6	25	19	44	50	31	16
L	32	40	12	23	27	18	25	32	41	40	56
											711

Autumn and *Spring*, Highs without Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	0	15	0	11	41	15	59	4	18	48	27
E	6	7	4	4	11	4	14	9	15	25	53
S	12	17	8	10	37	14	52	12	29	39	52
C	14	30	4	12	24	14	12	8	12	8	50
P	10	35	5	30	40	10	35	5	15	30	20
											202

Autumn, and *Spring*, Highs with Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	23	13	6	46	40	20	13	0	13	20	15
E	32	37	11	21	19	25	23	15	15	17	75
S	0	0	0	0	0	0	33	0	33	66	3
C	56	58	15	27	24	13	11	13	10	8	62
P	0	0	0	0	0	0	0	0	0	0	1
											156

Winter, Highs without Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	10	26	10	11	30	4	38	13	15	36	53
E	15	23	5	9	7	5	7	5	10	10	276
S	6	2	5	2	38	18	35	20	29	37	66
C	24	50	11	19	18	8	9	6	9	10	154
P	14	25	7	18	21	10	21	7	7	14	28
											577

Winter, Highs with Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET	Total Days.
W	25	50	25	50	58	25	25	0	4	8	24
E	43	64	19	31	22	11	5	7	11	7	74
S	0	0	0	0	0	0	0	0	0	0	1
C	66	81	22	36	28	24	14	9	9	5	64
P				None.							
											163

PRESSURE TYPES: CLOUD WHICH SHOULD BE PRESENT OVER EACH DISTRICT, BASED ON PERCENTAGES.

Summer, Highs without Lows.

Type	W	SW	C	S	SE	FS	N	WT	CT	ET
W	O	O	O	O	●	O	●	O	S	●
E	O	O	O	O	S	O	S	O	S	S
S	O	O	O	O	S	O	●	S	●	●
P	O	O	O	O	S	O	S	S	S	S
C	O	O	O	O	S	O	O	O	S	S

Summer, Highs with Lows.

W	O	S	O	O	S	O	●	O	S	S
E	O	O	O	O	O	S	S	S	S	S
S	O	O	O	O	S	O	O	S	●	●
C	O	S	O	O	O	O	O	O	S	S
P	O	O	O	O	O	S	O	S	●	S
L	S	S	O	O	S	O	S	S	S	S

Autumn and *Spring*, Highs without Lows.

W	O	O	O	O	S	O	●	O	O	S
E	O	O	O	O	O	O	O	O	O	S
S	O	O	O	O	S	O	●	O	S	S
C	O	S	O	O	O	O	O	O	O	O
P	O	S	O	S	S	O	S	O	O	S

Autumn and *Spring*, Highs with Lows.

W	S	O	O	S	S	O	O	O	O	O
E	S	S	O	O	O	S	O	O	O	O
S	O	O	O	O	O	O	S	O	S	●
C	●	●	O	S	O	O	O	O	O	O
P	O	O	O	O	O	O	O	O	O	O

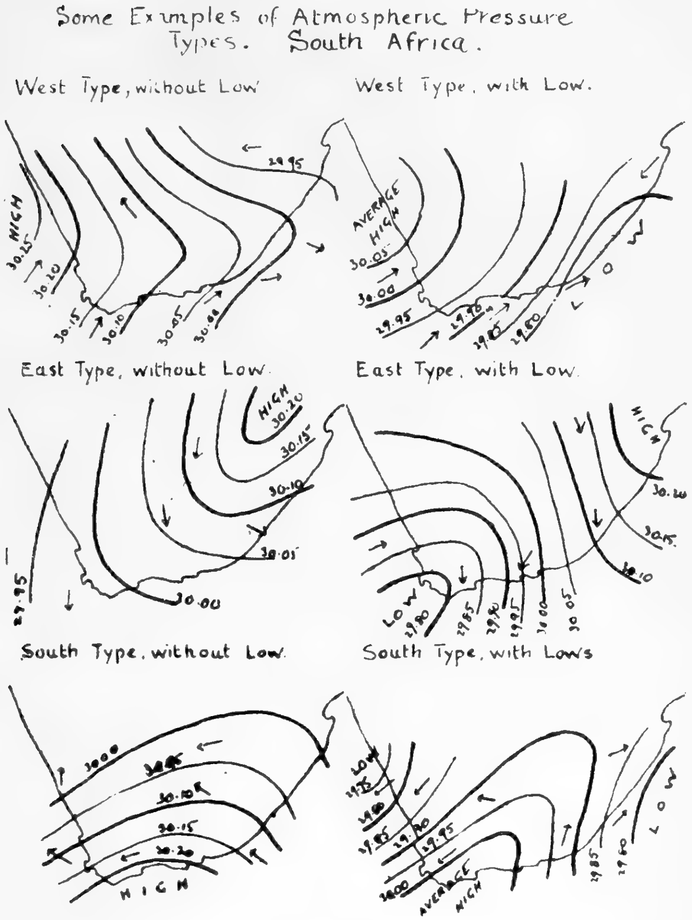
Winter, Highs without Lows.

W	O	S	O	O	S	O	S	O	O	S
E	O	O	O	O	O	O	O	O	O	O
S	O	O	O	O	S	O	S	O	S	S
C	O	O	O	O	O	O	O	O	O	O
P	O	S	O	O	O	O	O	O	O	O

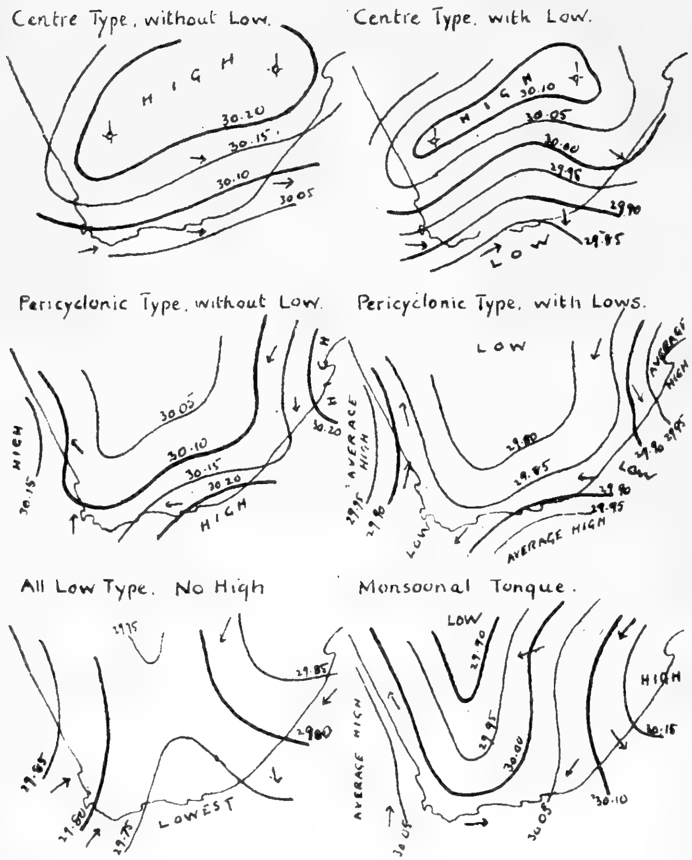
Winter, Highs with Lows.

W	S	●	S	●	●	S	S	O	O	O
E	●	●	O	S	O	O	O	O	O	O
S	O	O	O	O	O	O	O	O	O	O
C	●	●	O	S	S	O	O	O	O	O
P			None.							

Graphs of the various types of atmospheric pressures occurring in South Africa are given in the following text-figures:—



For graphs of the Central, Pericyclonic, and All Low types, see next page.


Centre Type, without Low.
HIGH
30.20
30.15
30.10
30.05
Centre Type, with Low.
HIGH
30.10
30.05
30.00
29.95
29.90
29.85
LOW
Pericyclonic Type, without Low.
HIGH
30.05
30.10
30.15
30.20
HIGH
30.15
HIGH
30.20
Pericyclonic Type, with Lows.
LOW
29.80
29.85
29.90
29.95
AVERAGE HIGH
AVERAGE HIGH
AVERAGE HIGH
LOW
LOW
All Low Type. No High
29.75
29.85
29.80
29.85
29.80
29.75
LOWEST
Monsoonal Tongue.
LOW
29.90
29.95
30.00
HIGH
30.15
30.10
30.05
30.05
AVERAGE HIGH

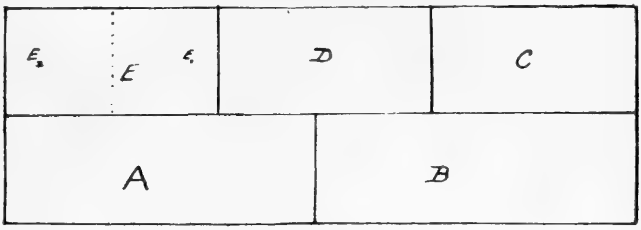
A PRELIMINARY REPORT ON THE VELD-BURNING EXPERIMENTS AT GROENKLOOF, PRETORIA.

By E. P. Phillips, M.A., D.Sc., F.L.S.

With 3 Charts and Plates XXXI-XXXIII.

Read July 11, 1919.

The area under observation is situated on the Experimental Farm at Groenkloof, and consists of an oblong piece of ground 35·5 morgen in extent, and which is divided into five plots, as indicated on the plan below.*



When I took over the work in August, 1918, the following data were available:—

A. Control plot and unburnt.
B. Unburnt, but mown (no date).
C. Burnt on 15-7-16 and 2-8-17.
D. Burnt on 1-8-16 and 1-7-17.
E. Burnt on 1-7-16 and 15-6-17.

I found, however, that the plot E had been burnt since June, 1917, evidently early in 1918, and that the burning on one half was of more recent date than on the other half. This being so, the plot was subdivided into two parts, E_1 and E_2, corresponding with the burns, and the more detailed work was done on these portions.

Each of the five plots was isolated from the adjoining plots by a fire break, and in the same way the whole area was isolated from the surrounding veld. Through a misfortune, a veld fire managed to cross the fire path and burnt the whole of the control plot A. This happened between August 4th and 11th, 1918.

Methods of Work.

The great difficulty which presented itself was the fact that I was unable to recognise the species in the very young state,

* In the plan, the lettering E_1 and E_2 should be interchanged.

i.e., when the leaves first appeared above the ground, and, as a knowledge of the succession of the species after a fire might have an important bearing on the problems of the change in the veld due to burning, I had to overcome this difficulty. The method adopted was to mark as many plants as possible as they appeared above the ground with a zinc label, about 6 inches long, driven into the ground at the side of the shoot. Each label was stamped with a consecutive number, and a book with corresponding numbers, and with sufficient space between the numbers to add notes, was kept for the records. As soon as the plants flowered they were identified, and in this way the rotation in which the various species appeared was known. This method also proved useful in enabling one to study more or less the life-history of the species. It is true the objection might be raised that it would be impossible to find all the labels again, but in practice I found that if the labels were used freely, the possibility of losing sight of any particular species during the whole period of observation was done away with. This method has also the advantage that the labels are permanent, so that when the plots are periodically burnt, they remain in the ground, and in this way one will be able to observe whether any species disappears or increases through constant burning.

The plots were visited almost regularly every Sunday, except during the month of October and part of November, when the prevailing influenza epidemic prevented my going out.

Observations, Plots E_1 and E_2.

Growth had already commenced on August 4th, and the plots were covered with young green shoots just appearing above the ground, but on E_2 (the earlier burnt portion) growth was more advanced than on E_1. The only plants in flower on E_2 were *Lasiosiphon linifolius*, *Gerbera piloselloides,* and *Gazania krebsiana*, but while these species were also noted on E_1, none had yet flowered. On both plots many grasses had begun to shoot. A week later (August 11th) *Gazania krebsiana* and *Lasiosiphon linifolius* were common in flower, especially at the lower end of the plot, where the soil is a rich red loam. *Gerbera piloselloides* was seen occasionally in flower as well as *Moræa* sp. On E_1 only a single specimen of *Gazania krebsiana* was seen in flower. The following week (August 18th) there was a marked change on both the plots E_1 and E_2, and this was more apparent on E_1, where many of the species common on E_2 were beginning to appear. E_1 really carried the same species, but in a less advanced stage of development. On E_2, *Gazania krebsiana and Lasiosiphon linifolius* still retained the position as the species flowering most freely, and were now followed in this respect by *Gerbera piloselloides*. The following additional species were taken in flower on E_2:—*Becium obovatum*, *Felicia muricata*, *Indigofera hedyantha*, *Tulbaghia acutiloba*.

Moræa sp. was still in flower, but many individuals had begun to form fruits. *Hermannia depressa* and *Scilla* (*lancæfolia*?) were coming into flower, while numerous shoots of *Vernonia natalensis* were appearing above the ground.

A single bush of *Elephantorhiza Burchellii* was found with young shoots just appearing. This species eventually became very common.

The plots were not visited again until September 4th, and the most noticeable change was the fact that *Gerbera piloselloides* had replaced *Gazania krebsiana* and *Lasiosiphon linifolius* as the dominant flowering plant. The two latter species were now on the wane. In several places *Gerbera piloselloides* formed distinct clans. Another change noticed was the advanced growth of *Vernonia monocephala*, which was seen in flower frequently, but the majority of the plants were in bud. There was also a marked difference in the development of *Vernonia lasioclada*, but none of the individuals had yet flowered. Scattered over both plots were plants of *Hypoxis rigidula* in flower, and on some parts these grew in more abundance. *Thesium utile* was another species which was now frequent, and several plants of *Scilla* (*lancæfolia*?), some in bud, some in flower, were common.

The increase in the number of individuals of *Scilla* (*lancæfolia*?) was the most important change observed the following week (September 15th), but most of the plants were still in bud. *Bulbostylis trichobasis,* a small plant 2 to 3 inches high, was now very common. Among the first species to make their appearance after a fire is *Becium obovatum,* which was now flowering freely. *Indigofera hedyantha* was freely in bud, occasionally in flower, and plants of *Diplopappus* (*Aster*) *serrulatus* were frequently in bud. Besides *Hypoxis rigidula*, a single specimen of *H. angustifolia* was found, and many plants of *H. multiceps* were coming into flower. *Hermannia depressa* and *Lasiosiphon linifolius* were flowering frequently, and occasionally seen in bud. The first grass to flower was *Eragrostis chalcantha*, which was very common. This grass is undoubtedly a pioneer, as almost every hard bare patch has been invaded by this species. In this respect it differs from *Cynodon dactylon*, which colonises loose ground, such as broken-down ant heaps.

During the following week growth appears to have been very rapid, especially in *Vernonia lasioclada,* which on September 22nd formed a vernal aspect society on the plot E_1, but none of the individuals were yet in flower. Among this species, plants of *Becium obovatum*, *Indigofera hedyantha, Lasiosiphon linifolius, Felicia muricata, Indigofera hilaris,* are common. *Oldenlandia* (*Hedyotis amatymbica*) was frequent. At the lower end of the plot, on a red loamy soil, were many plants of *Aster* (*Diplopappus serrulatus*) in mature bud; only one individual was observed with an open inflorescence. This species was almost entirely absent from the upper portion of this plot, where the soil is of a yellow colour. *Hermannia depressa*.

which is frequent on E_2, was not observed on the adjoining plot E_1. *Felicia muricata,* mentioned above as one of the common species, was fruiting in a great many cases, and all the plants of *Moræa* sp. had finished flowering. *Bulbostylis trichobasis* had also finished flowering; the dry empty anthers still remained attached to the inflorescence. Although *Eragrostis chalcantha* was so common, and had begun to produce inflorescences some time back, none of the flowers had matured yet. It is the first grass to flower, but a long interval elapses between the first appearance of the inflorescence and the opening of the florets.

As the vernal aspect of *Vernonia lasioclada* was the conspicuous feature on the plot E_1 the previous week, I found on September 29th that the vernal aspect of plot E_2 was due to *Hypoxis rigidula.* The first flowering species, viz., *Gazania krebsiana,* was rapidly disappearing, but *Gerbera piloselloides* was still frequently in flower, though not so common as it was a little while previously. *Scilla* (*lancæfolia*) and *Becium obovatum* were both still very frequent in flower, while *Indigofera hilaris* and *Anthistiria imberbis* were coming into flower rapidly. The latter is the dominant grass on the plot. *Elephantorhiza Burchellii* was growing very rapidly, and was exceeding common, while *Aster* (*Diplopappus serrulatus*) was flowering more freely, but was by no means common. Several specimens of *Dimorphotheca spectabilis* were in flower, and occasionally plants of *Bopusia subintegra* were observed in flower. Among the rarer species was *Eulophia inæqualis*, of which only two specimens were seen. While *Vernonia lasioclada* was so very common, being the only plant seen from a distance, it is late in flowering, as only one mature inflorescence was found. On October 13th I found that *Pentanisia variabilis, Indigofera hilaris, Hypoxis rigidula,* and *Lasiosiphon linifolius* were the most common plants in flower. *Gaziana krebsiana* and *Vernonia monocephala,* formerly two of the most common species, were now almost over. The other common species, besides those mentioned above, were *Helichrysum coriaceum* and *Solanum panduræforme,* both of which were coming into flower rapidly. The red soil at the lower end of the plot bears a more luxuriant vegetation, and on this portion *Elephantorhiza Burchellii* and *Indigofera hilaris* were the two dominant species.

I was unable to visit the plots for about six weeks, and during this interval the whole aspect had changed. On December 1st I found that almost all the smaller shrubs and herbaceous plants had disappeared, and their place was taken by *Anthistiria imberbis* and *Scabiosa columbaria.* The former was now the dominant species and the latter very common, its flowers showing conspicuously above the grass. Among the grass, plants of *Elephantorhiza Burchellii,* and *Vigna angustifolia* were very common. *Vernonia lasioclada, Eragrostis chalcantha, Hypoxis multi-*

ceps and *Indigofera hilaris* had all* finished flowering, and were not nearly so common as they were before *Anthistiria imberbis* took possession. *Scabiosa columbaria* was among the first species to appear after the burning, but was the last to flower.

Anthistiria imberbis does not remain in possession long, as on February 8th (1919) it had finished flowering, and its place was taken by other grasses. *Scabiosa columbaria* disappears with *Anthistiria imberbis*, as not a single specimen was to be seen on the above date. The only plant in flower which was conspicuous above the grasses was *Senecio latifolius*, and occasionally a few specimens of *Oxalis sp.* were observed. The dominant grasses now were *Andropogon amplectens*, *A. schirensis*, var. *angustifolius*, and *Trachypogon polymorphus*. Among the dominant grasses *Digitaria diagonalis*, *Panicum natalense*, *Diplachne biflora* and *Anthistiria imberbis* (finished flowering) were common. Occasionally were observed specimens of *Urelytrum squarrosum*, *Andropogon hirtiflorus*, and *Setaria perennis*, while *Tricholæna setifera* was rare.

This stage, I think, represents the highest development on the plots E_1 and E_2.

Summary of the Life History of Plots E_1 and E_2.

The life history of the vegetation existing on the plots E_1 and E_2 is very similar, with the exception that the more recently burnt plot, namely, E_1, was slightly behind in the time at which the dominant species appeared in flower, but they can be treated as a whole quite conveniently. *Gaziana krebsiana* and *Lasiosiphon linifolius* are the first dominant species with *Gerbera piloselloides* and *Moræa sp.* as sub-dominants. Two weeks later many other species made their appearance, but were not flowering. At the beginning of September *Gerbera piloselloides* was flowering freely, and usurped the place of *Gaziana krebsiana* and *Lasiosiphon linifolius* as the dominant plant in flower. From now until the middle of September the common species grow rapidly, but this is most noticeable in *Hypoxis rigidula* and *Vernonia lasioclada*, and the latter species now becomes dominant, so much so as to form a vernal aspect society, and by this time *Gerbera piloselloides* has almost disappeared. Towards the end of September *Hypoxis rigidula* comes into flower very rapidly, and forms a vernal aspect society in place of *Vernonia lasioclada*. While these changes are taking place the sub-dominant species, such as *Indigofera hilaris*, *Becium obovatum*, *Vernonia monocephala*, *Elephantorhiza Burchellii*, and *Helichrysum coriaceum* are much in evidence. During October and November the flowering shrubs, etc., have set fruit and died down, and *Anthistiria imberbis* with *Scabiosa columbaria* take possession. This does not last much longer than six or seven weeks, and the *Anthistiria imberbis* is

* I saw a single specimen of *Eragrostis chalcantha* in flower on February 24th, 1919.

replaced by *Andropogon amplectens, A. schirensis,* var. *angustifolia* and *Trachypogon polymorphus.*

PLOTS A, B, C, AND D.

Though it was unfortunate that the control plot A was accidentally burnt, yet it was interesting to note the same life-history taking place in the succession as was observed on both the plots E_1 and E_2, but the order of succession was slightly different. The various species, such as *Gazania krebsiana, Lasiosiphon linifolius, Gerbera piloselloides,* etc., which appeared in such definite succession on E appeared here more or less at the same time. The only fact perhaps worthy of note was the large number of plants of *Oldenlandia* (*Hedyotis amatymbica*), which was far more common than on either E_1 or E_2. After passing through the various phases as noted in E_1 and E_2, but only in a less marked degree, the area is taken possession of by grasses. The two vernal aspect societies produced by *Vernonia lasioclada* and *Hypoxis rigidula* do not appear at all so markedly, and also the small shrubs, such as *Elephantorhiza Burchellii, Indigofera hedyantha, Vernonia lasioclada,* are not nearly so common. In the final stage of the succession by far the most dominant grass was *Trachypogon polymorphus.* The other dominant species were *Andropogon amplectens* and *A. schirensis,* var. *angustifolia. Panicum natalense* is very common; *Andropogon nardus* and *A. hirtiflorus* common. Occasionally may be seen plants of *Tricholæna setifera,* and more rarely *Digitaria diagonalis.* On this plot *Anthistiria imberbis* is of very secondary importance, and in some localities almost completely absent. These observations bear out the statements by Bews that *Anthistiria imberbis* is not a stable stage; but, if left undisturbed, gradually gives way to the tall species of *Andropogon*, a stage in the succession to bush. On all the other plots which had been burnt *Anthistiria imberbis* was at one period of the succession the dominant grass, but this was not the case on A, which has not been burnt for at least two years, and probably longer.

Bews's observations that grass-burning has the effect of increasing the abundance and extent of vernal aspect societies has also been verified. As I pointed out when dealing with the plots E_1 and E_2, this is seen in *Vernonia lasioclada* and *Hypoxis rigidula,* but whilst not definite on A, and the same applies to the plots B, C, D, which were not burnt last year at all.

On the plot D the dominant grasses are *Trachypogon polymorphus* and *Anthistiria imberbis.* The former, being a tall grass, overtops the *Anthistiria,* which is not seen unless one walks through the plot. *Panicum natalense* is common, while *Andropogon nardus* is only occasional. The grasses *Digitaria diagonalis, Elionurus argenteus, Andropogon amplectens* are rare, while only a few specimens of *Panicum serratum* were observed on old ant-heaps. *Vigna angustifolia* is a very common shrub, but, except in very rare cases, had finished flowering. *Pentanisia*

variabilis is frequent, and *Hypericum æthiopicum* rare, both being found only in open patches.

The plot C is much the same as D, but *Anthistiria imberbis* is more prominent, and in some patches it grows to the exclusion of *Trachypogon polymorphus*. On the whole, the grass is not so luxuriant as on D, and *Vigna augustifolia* appears to be more common, though this may only be due to the fact that the tall *Trachypodon polymorphus* does not dominate to the same extent as on D, and the bushes are better seen among the shorter *Anthistiria*. At the upper right-hand corner of the plot *Anthistiria imberbis* is the sole dominant grass, and hardly a specimen of *Trachypogon polymorphus* is to be seen amongst it. In one locality a clump of *Andropogon Buchanani* grows amongst the *Anthistiria*..

Photographs of the vegetation were taken from time to time, and are reproduced in Plates XXXI-XXXIII.

Temperature Records.

Temperature readings were made with a view to finding out how a dense covering of vegetation affected the temperature of the soil. The method adopted has not given absolute results; but, as the conditions under which the readings were taken were the same in each case, I think the results obtained can be fairly compared. Two holes, about 12 inches deep and about 50 yards apart, were dug, one on the plot D (densely covered with *Anthistiria imberbis*), and the other on E_1 (which was bare owing to it being recently burnt). In an oblong tin I fixed a maximum and minimum thermometer, and placed the tins in the holes. Both tins were covered with about 3 inches of soil, and in addition that on D was covered with grass. A third maximum and minimum thermometer, fixed in exactly the same way, was placed in an exposed place so that it had no shade during the day. All the thermometers were read, as far as possible, once a week, and the following are the results:—

DEGREES F.

1918-19.	AIR.			D.			E_1.		
	Max	Min	Diff.	Max.	Min	Diff.	Max	Min.	Diff.
September 15th ...	85	48	37	63	50	13	70	56	14
„ 22nd ...	88	55	33	67	58	9	77	63	14
„ 29th ...	85	54	31	68	57	11	78	62	16
October 9th ...	86	51	35	66	59	7	80	60	20
„ 13th ...	90	58	32	69	61	8	84	65	19
November 24th ...	94	50	44	75	59	16	94	57	37
December 1st ..	91	55	36	76	56	20	88	59	29
„ 15th ...	96	54	42	78	56	22	93	63	30
„ 29th ...	98	58	40	74	67	7	93	67	26
February 8th ...	94	52	42	76	66	10	92	64	28

During the period September 15th, 1918, to February 8th, 1919, in which the readings were taken, the temperature of E_1 was on the average, 13.7° F. during the day and 3.5° F. higher during the night than D. The greatest difference during the day was during the weeks ending November 24th and December 29th, when the temperature of E_1 was 19° F. higher than that of D. The smallest difference was during the week ending September 15th, when E_1 was only 7° F. higher than D.

During the day, D was, on the average, 19.5° F. lower in temperature than the air, while E_1 was only 5.8° F. lower. During the night this was reversed, as D was only 4.4° F. higher than the air, while E_1 was 8.1° F. higher.

These data are graphically represented in the charts to be found at the end of this paper.

The conclusion seems to be that the soil, denuded of its vegetation by burning, absorbs more heat during the day, and the radiation during the night is not sufficient to lower the temperature to that of soil thickly covered with vegetation, so that it is warmer both during the day and night than a soil covered with vegetation.

On the other hand, both the day and night temperatures of the soil covered with vegetation show less variation, as will be seen from the accompanying curves.

Soil Moisture.*

The data on the amount of soil moisture contained in the soils on the various plots has not been obtained in sufficient detail to draw any definite conclusions as to the effect of denuding a piece of ground of its vegetation by burning. Also, the fact that I had taken the rainfall records at Pretoria, and not at Groenkloof, has led to an error, which is clearly seen when plotting the curve showing the increase of water content in the soil with increased rainfall. In one instance there was an increase of 0.70 inch in the rainfall at Pretoria; but the moisture contents of the soil dropped considerably, and I can only conclude that no rain fell at Groenkloof during the period.

There are two facts, however, which I think may be safely deduced from the scanty records, and these are:—

1. In plots bearing no vegetation, the water content of the soil rises far more after rain than on plots covered with vegetation, but the water is lost again more rapidly. This can be seen from the curve indicating percentage of moisture on the plots A and E_1 (both bare plots), as compared with C, D, and E_2. In none of the latter is there such a sudden absorption and loss of water; the water content remains more uniform.

* The analyses were kindly made for me by Dr. B. de C. Marchand, of the Division of Chemistry, Pretoria.

Summary.

1. The burning of the veld and denuding the soil of its protective vegetation tends to encourage the flowering of many plants, particularly hemicryptophytes, by allowing the access of light and warmth. In the development of the succession on the burnt portion there appears to be a definite life history, and the formation of vernal aspect societies. *Anthistiria imberbis* at first is the dominant grass, but there is an invasion later of *Trachypogon polymorphus* and *Andropogon spp.*, and on portions left unburnt for several years the latter species tend to replace the *Anthistiria imberbis.*

2. On bare soil the temperature during the day is considerably higher than on soil covered with vegetation, and the same at night; but, taking the daily maximum and minimum temperatures, then soil protected by a covering of vegetation has a more even temperature, and does not exhibit such extremes of heat and cold.

3. Soil denuded of its vegetation absorbs more water after rain than does soil covered with vegetation, but also loses it more quickly by evaporation; whereas soil with a protective covering of vegetation, while not absorbing the same amount of water after a rainfall, loses its water more slowly, and consequently does not fluctuate between a very high and very low moisture content, but is more stable in this respect.

The few observations made during the latter part of last year at Groenkloof are the beginning of a series of experiments being carried out there by the Division of Botany. I realize that at this stage it is too early to draw any but very general conclusions; but this note has been published only with the intention of placing on record the observations made up to the present.

Data relating to the mechanical and chemical examination of soils from plots A, B, and C, as determined by Dr. C. F. Juritz, are appended.

Copy.

Agric. Chemical Research Laboratory,
Department of Agriculture,
Cape Town, 15th April, 1919.

The Chief, Division of Botany,
Pretoria.

I subjoin particulars in regard to the mechanical and chemical examination of the three samples of virgin grass-veld soil, A., B. and C., from the Drylands at Groenkloof, near Pretoria, sent under cover of your minute No. P.115/18 of the 26th September last.

The ground, I understand from your minute, slopes very gently down to the Groenkloof Valley, and at the lower end of the area—about 100 yards square—whence the samples were taken, the soil is red in colour and almost level. It was from this lower end of the area, I gather, that sample C. was taken, while A. and B. were taken from its upper end, where the ground is very stony and of a light yellow colour.

The samples were described as follows:—

A. Stones near surface. Soil yellowish, either very little change or may change to a yellowish brown after the first two inches.
B. Soil yellowish for 8 inches and then darker yellow, stony as sample A.
C. Soil reddish, not stony.

Mechanical analysis of these three samples yielded the results tabulated below:—

The percentage composition of the samples as collected in the field, after drying, was as follows:—

	Stones above 3 mm.	Coarse gravel. 3-2 mm.	Soil below 2 mm.
A.	37.85	3.11	59.04
B.	26.84	5.57	57.59
C.	nil.	0.26	99.74

The above 2 mm. product, on further differentiation, was found to be composed as follows:—

	Fine gravel 2-1 mm.	Coarse sand 1-.5 mm.	Medium sand .5-.25 mm.	Fine sand .25-.1 mm.
A.	10.16	20.20	29.31	17.85
B.	9.67	20.42	27.12	14.77
C.	12.74	23.70	29.20	17.33

	Very fine sand .1-.05 mm.	Silt 05.-.01 mm.	Fine silt .01-.005 mm.	Clay below .005 mm.
A.	10.16	20.20	29.31	17.85
B.	9.67	20.42	27.12	14.77
C.	12.74	23.70	29.20	17.33

It will be seen that after sifting away the pebbles and coarse gravel the mechanical make-up of the residual soils is very similar. This becomes more obvious on stripping of their decimals the percentages in the last table, thus:—

	Fine gravel	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt	Fine silt.	Clay.
A.	5	3	6	8	10	20	29	18
B.	8	4	8	8	10	20	27	15
C.	2	2	6	7	13	24	29	17

Grouping all the sand grades together, and likewise the silt grades, the following figures are arrived at:—

	Fine gravel.	Sand.	Silt.	Clay.
A.	5	28	49	18
B.	8	30	47	15
C.	2	28	53	17

C. is therefore very slightly finer-grained than A. or B., but I would class all three as fine-grained loam soils, almost approaching to silt-loams, but all three clearly belong to the same series. The high percentages of silt render such soils as C. valuable for wheat cultivation (leaving the chemical composition of the soil out of consideration for the moment). In the United States, the Norfolk silt loam is regarded as one of the most valuable soils of the Atlantic coastal plain for general farm crops, and is best adapted for wheat, maize and grass; its average mechanical composition is:—

Fine gravel.	Sand.	Silt.	Clay.
1	31	54	12

Another American soil that is physically very similar to A. and B. is the stony loam of the Miami series, which contains from 20 to 60 per cent. of rounded and angular stones varying from 1-8 inches in diameter. This soil, too, is very productive, producing, amongst others, good crops

of maize, wheat and grass and affording excellent pasture. The percentage composition of this soil (below the 2 mm. grade) is as follows:—

Fine gravel.	Sand.	Silt.	Clay.
2	34	47	17

It should be added that the Miami soils are derived directly from the fine silty deposit as "loess"—a friable calcareous loam, filled with minute tubular pores which are lined with calcium carbonate. Chemically, the Groenkloof soils differ considerably from this type. In fact, chemically, the Groenkloof soils leave much to be desired, as the following analytical results show:—

	Percentage of soil sifted through				Percentage of soil sifted through ½ mm. sieve.			
	Moisture	Loss on Ignition	Nitrogen	Potash	Lime.	Magnesia.	Phosphoric Oxide soluble in cold Hydrochloric Acid	Oxide soluble in boiling Nitric and Sulphuric Acids.
A.	1.51	9.70	·148	.040	.060	.042	.029	·081
B.	2.19	7·30	·123	.048	.104	.084	.050	·118
C.	1.68	10.25	.149	.032	.046	·037	.039	.093

Except where otherwise stated, the inorganic plant food constituents in the above table were extracted from the soil by means of cold hydrochloric acid.

The moisture and loss on ignition were also determined in respect of the soil as sifted through a *half* millimetre sieve, with the following percentage results:—

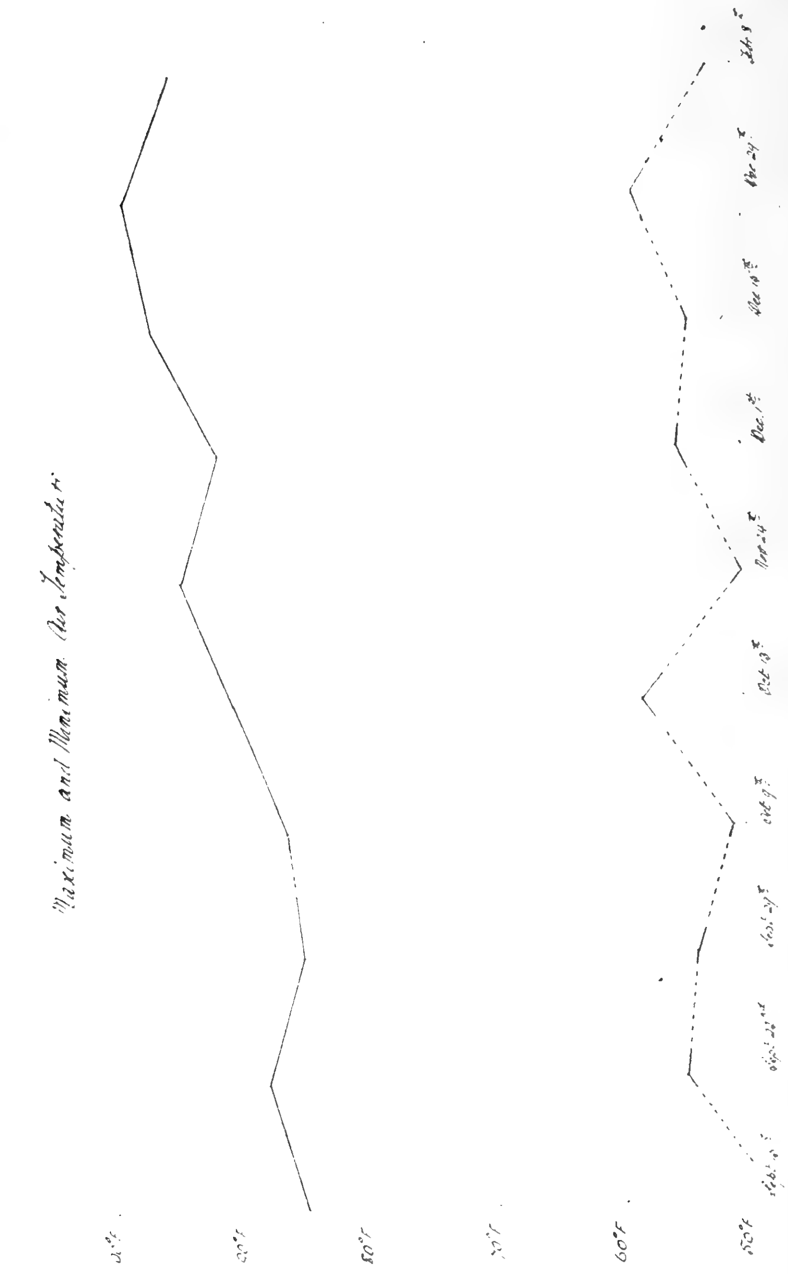
	Moisture.	Loss on Ignition·
A.	1.52	8.83
B.	1.27	7·21
C.	1.60	9.54

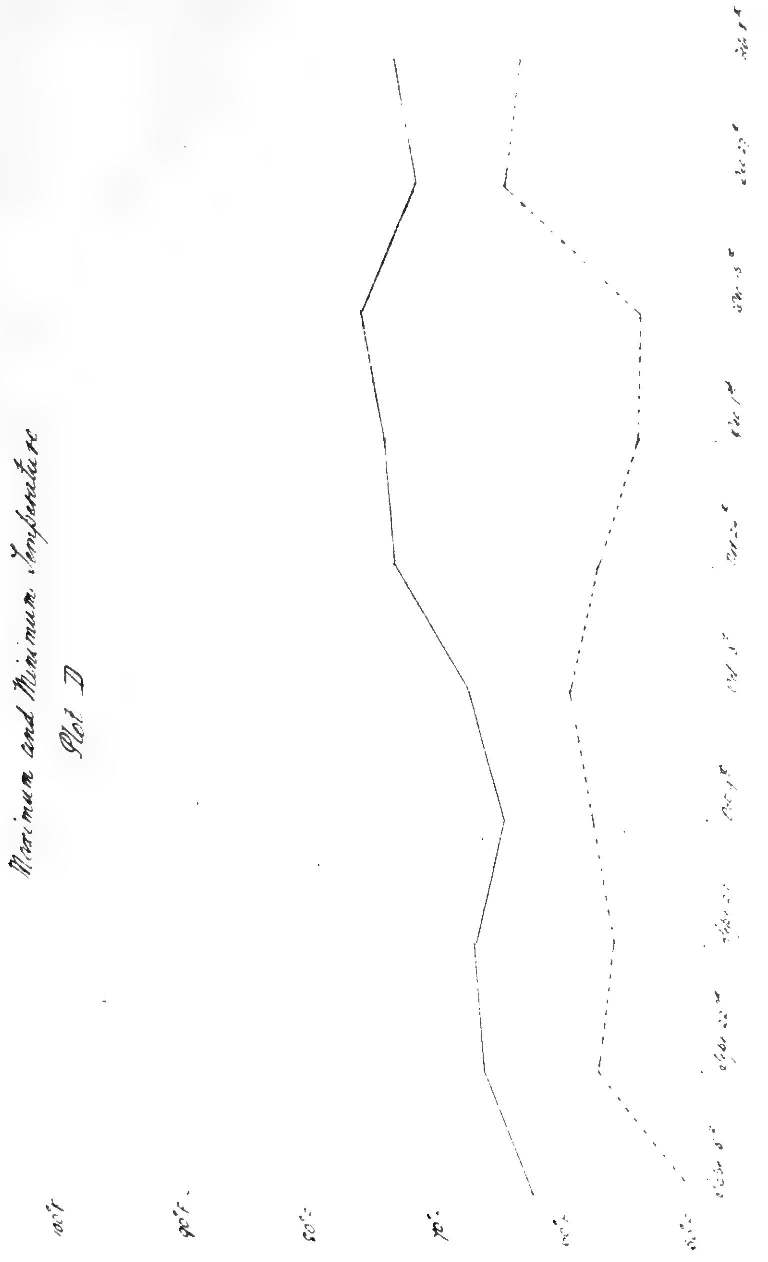
These soils cannot be described as good from the chemical viewpoint: their humus content is not very high, and accordingly the nitrogen percentage and retentive power for moisture are only fair. In all the inorganic constituents of plant food they are defective, B. being the least poor of the three, although the difference is really inappreciable.

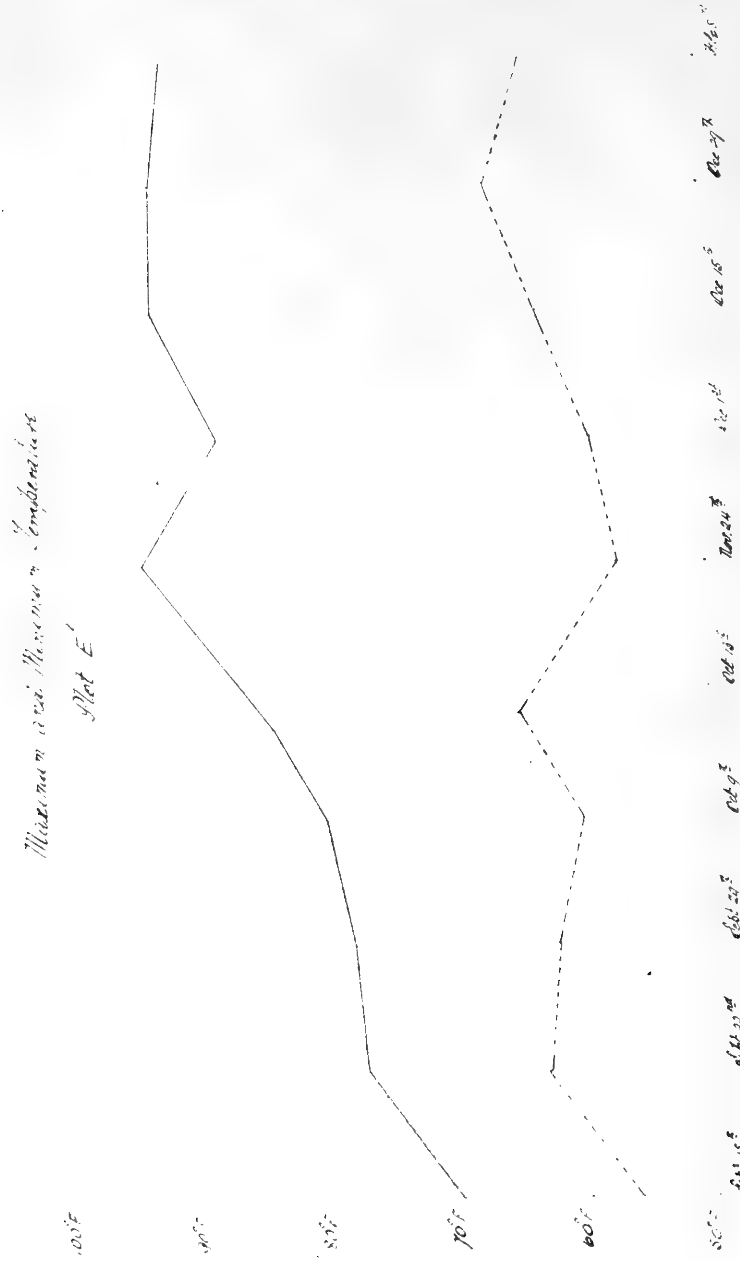
I should like to know as nearly as possible from which part of the farm the samples were taken in order that any connection between the soil and the underlying geological formation may be noted. The northern and eastern portions of the farm comprise, I believe, quartzites and shales of the Pretoria series, while the south-western part—roughly the part south and west of Fountains—consists of dolomitic limestone and shales·

(Sgd.) Chas. F. Juritz,
Agricultural Research Chemist·

Charts showing maximum and minimum temperatures, and rainfall and percentages of moisture in the soil are given on the succeeding pages 296-299.

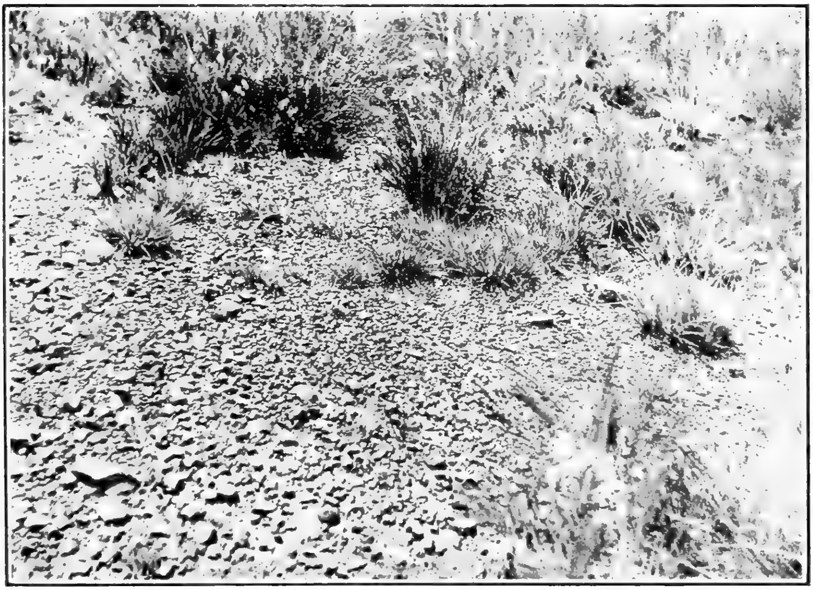

Maximum and Minimum Air Temperature
80°F
60°F
50°F


Maximum and Minimum Temperature
Plot D


Plot E
70°F
60°F
Sept 22nd
Oct 9th
Oct 15th
Nov. 24th

Anthistiria imberbis, Retz., on Plot B. 29/12/18.

(*Photo by E. P. P.*)



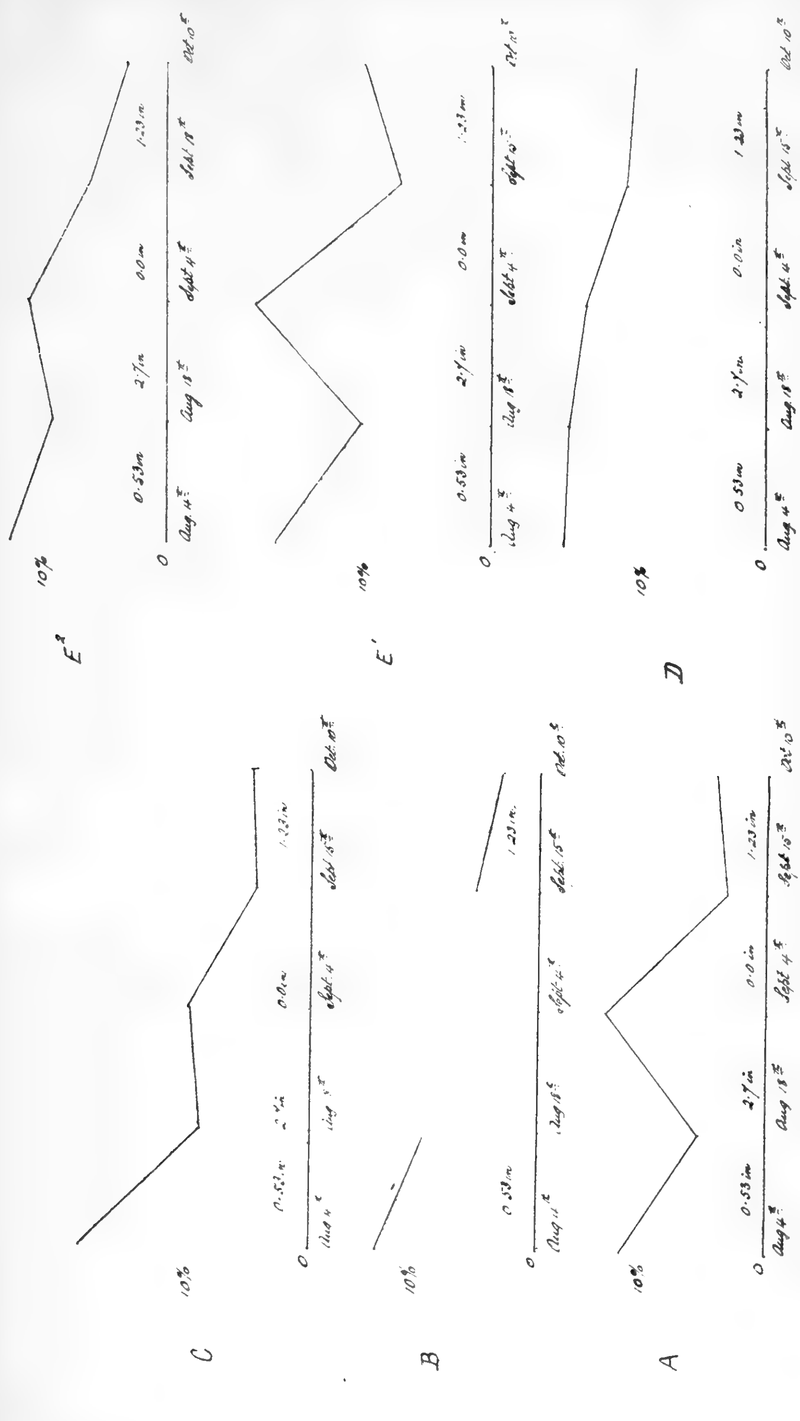
Eragrostis chalcantha, Trin., as a pioneer on bare patches.

Anthistiria imberbis, Retz. Looking towards Plot D. 29/12/'18.
(*Photo by E. P. P.*)

Cynodon dactylon, Pers., in possession of broken-down ant-heap in field of *Anthistiria imberbis*, Retz.

Anthistiria imberbis, Retz., with *Scabiosa Columbaria,* Linn., on Plot E_2. 15/12/18.

Vernonia lasioclada Hutch. (middle foreground), forming a vernal aspect society. In foreground clumps of *Anthistiria imberbis,* Retz.



RAINFALL AND PERCENTAGE OF MOISTURE IN SOIL.

MUTATIONS AND EVOLUTION.

By J. E. Duerden, M.Sc., Ph.D.,

Professor of Zoology, Rhodes University College, Grahamstown; Officer-in-Charge, Ostrich Investigations, Grootfontein School of Agriculture, Middelburg, C.P.

Read July 7, 1919.

The variations with which the mutationist has hitherto been mainly concerned are those of an isolated, discontinuous kind, and it is generally assumed that they arise from factorial changes, the result of mitotic irregularities during gametogenesis. Thus, in his Presidential Address before the British Association in Australia in 1914, Prof. W. Bateson* remarks: "The isolated events to which variation is due are evidently changes in the germinal tissues, probably in the manner in which they divide. It is likely that the occurrence of these variations is wholly irregular, and as to their causation, we are absolutely without surmise or even plausible speculation."

Probably most species show numbers of disconnected mutations which have arisen in this way. For the most part they represent small individual differences, germinal in their nature, and fluctuating about a mean. Prof. H. S. Jennings† states: "All thorough work has led directly to this result, that any species or kind or organism is made up of a very great number of diverse stocks, differing from each other in minute particulars, but the diversities inherited from generation to generation." Prof. M. Caullery‡ also remarks: "A species is nothing but the sum of an infinity of genotypes differing very little from one another." If the germ plasm of the species is in a fixed and stable condition, then isolation of the pure germinal forms, genotypes, showing the separate differences, becomes possible, as in Johannsen's well-known experiments with beans and those of Jennings with *Paramœcium;* but if it be in a changeable state, as in Jennings' work on *Difflugia corona,* genetic analysis into fixed pure races is naturally impossible. How far the germ plasm of a form is stable or unstable for the time being is a matter of observation and experiment.

These small variations are the germinal fluctuations of a species, and under ordinary circumstances the species will be limited to a mixed population of this kind. Most of the differences will be indifferent as regards their influence on the welfare of the individual, and no change will take place in the average assemblage; if, however, among them one or more

* "Science," Vol. XI., Aug. 28, 1914, p. 301.
† "Journn. Wash. Acad. Sc.," vol. VII, May 19, 1917, p. 282.
‡ "Science," vol. XLIII, April 21, 1916, p. 556.

variations should confer some advantage, the individuals possessing them may be expected to become more numerous, and in time we may get an assemblage, all the members of which will have undergone the transformation. If the character is distinctive enough it will be held that specific diversity or evolution has taken place, though without any intensification of the original mutation apart from a numerical one. Writing from the mutation standpoint, Prof. T. H. Morgan* is quite clear as to the conditions under which evolution may be expected to take place: "The mutation process rests its argument for evolution on the view that among the possible changes in the genes, some combinations may happen to produce characters that are better suited to some place in the external world than were the original characters." Variations having arisen as a result of genetic changes, natural selection then determines which will survive, or the course which evolution will pursue. But the genetic changes themselves are the basis of evolution, and the elimination of the unfavourable is merely a directive influence. Mutations give the material of evolution and natural selection determines its course.

From the above it would appear that transformation of a race can take place only when the mutations are of *advantage* to the individual; the vast multitude of indifferent changes which produce diversity are not the materials upon which the course of evolution depends. Such a view, however, takes no account of the possibility of a dominating recurrence of the same mutation or combination of mutations within a race apart from any advantage considerations. The attitude can perhaps be understood, for hitherto but scanty experimental evidence has been forthcoming in favour of a general recurrence of any particular mutation. A certain degree of repetition is sometimes observable, as several workers have pointed out in *Drosophila*, and as de Vries† has shown for the peloric toad-flax, but little to indicate a determinate dominance of any one change over the others. It must be admitted that if a germinal change is altogether dependent upon some purely fortuitous factorial irregularity, there can be little ground for expectation that it will occur again and again. But if it should be determined by some intrinsic condition or influence connected with the germ plasm of the race, a change having been effected once affords a strong likelihood of its repetition in other individuals, and it may even come to represent a dominating influence and ultimately transform the whole assemblage. Without being of any selection value, a mutation may recur so often that in time it comes to replace the original form, and we may get the gradual evolution of a new

* "Evolution by Mutation," "The Scientific Monthly," vol. 7, July, 1918, p. 51.

† "Species and Varieties: Their Origin by Mutations," London, 1905, p. 479.

species with characters having no particular advantage over the old.

Conditions represented at the present time by the two-toed African ostrich, *Struthio,* appear to throw some light upon the various kinds of mutations to which a race may be subject, and the nature of the evolution which it may undergo in consequence. They seem to afford strong support for the view that intrinsic mutations may arise quite apart from any adaptive or utilitarian considerations, and ultimately come to influence the race either as a whole or in part without the invocation of natural selection. Discontinuous mutations, deemed to have been of a recurrent nature, now serve to distinguish the northern race from the southern, while successional cumulative mutations of a degenerative nature affect the race as a whole, with differences of degree represented by different strains. In addition, individual ostriches and strains present the infinity of small, germinal variations characteristic of species generally.

Individual or Strain Mutations.

The small, fluctuating, germinal differences are well exemplified by the valuable plumes of the ostrich, which call for an intensive study on the part of the ostrich breeder. An almost indefinite number of variations are represented, connected with the dimensions, shape, density, texture, strength and lustre of the feather as a whole, as well as of its constituent parts—shaft, barbs and barbules. These constitute the "points" of the feather expert, and can often be differentiated only by the trained eye. From practical experience the breeder knows full well that the smallest structural details of the plumes are hereditary, and that the most desirable of them must either be present or "bred into" his flock if he is to succeed; he can only modify his strains by crossing with other equally fixed strains. Differences dependent upon feeding and the general management of the birds are afforded in plenty, the feather growth being extremely sensitive to the nutritive condition, but these are not part and parcel of the fixed constitution of the flock. Other structural parts of the body would no doubt be found to be as minutely variable as are the plumes, but have not called for the same special study. In its plumes alone the ostrich unquestionably supports Prof. Caullery's dictum that "a species is nothing but the sum of an infinity of genotypes," and the minute fluctuating variations may well be the result of small mitotic irregularities during gametogenesis.

While in farming practice the small plumage variations determine which birds will be used as breeders, in a state of nature it is impossible to conceive of any circumstances in which they could have any bearing on the welfare of the individual. They manifestly represent small, casual, germinal changes, very

limited as regards their somatic effect, which have arisen quite apart from any adaptive considerations, and are therefore beyond the realm of natural selection, and have no bearing on the evolution of the ostrich. However small the changes may be, they are, nevertheless, held to represent discrete factorial differences, and, following the views of Prof. T. H. Morgan, must be comprised under the category of mutations or saltations. Similar variations occur in both the northern and southern birds, so that corresponding germinal changes must have recurred in different members or strains of the race. In any region intermingling of the different types has freely taken place, but, until artificial selection was introduced, no one line of variation presented any particular ascendency over another. Recently domesticated birds in East Africa, reared directly from wild chicks and uninfluenced by any farming selection, have been found to be just as variable in their plume characters as are those in North and South Africa.

Racial of Specific Mutations.

Whether we regard the North African and the South African ostrich as two distinct species, or only as sub-species or varieties, each has a combination of well-defined differences which are germinal in origin. These variations are manifestly of a different category from those above mentioned, and indicate factorial changes of a more embracive nature. The northern bird is larger than the southern, and differently coloured, and displays a bald head in place of one wholly covered with hair-like feathers; the hen also lays larger and perfectly smooth eggs compared with those of the Cape bird, which are strongly pitted and more oval in shape.* The characters of the northern bird are retained under southern conditions, and reappear in the progeny; also the two freely interbreed, and the hybrids are fertile in every respect. The bald head patch behaves as a homozygous unit character, being dominant in first crosses and segregating normally both in the F_2 generation, and when crossed with the southern recessive. In first crosses the other distinguishing characters—dimensions, colours and egg-shell—appear as intermediates of varying degrees, but the slow attainment of maturity of the ostrich, at about three years, has not yet permitted of their analysis in later crosses.

With full knowledge of the habits of the ostrich and of the many vicissitudes to which it is subject in nature, it is hardly possible to conceive of any circumstances in which the characters distinguishing the two species could be of any adaptive or utilitarian value. The wild bird is subject to many harmful influences from the egg stage onwards, such as carnivora, droughts and parasites, with none of which the features mentioned could have any concern. They appear to represent merely isolated

* "Journal of Heredity," vol. ix, Oct., 1918, p. 243.

germinal differences which have appeared in the past, wholly apart from any considerations of welfare, and now serve to demark the ostriches of the more extreme parts of the continent. An intermingling, however, occurs in intermediate geographical areas, as indicated by the intermediate characters of the other two species which have been erected, namely, the East African ostrich, *S. massaicus,* and the Somali ostrich, *S. molybdophanes.*

If we concede that the ancestral ostrich had uniform characters, and that the differences which have since arisen are of no welfare value, the latter cannot have become dominant as a result of natural selection. We shall have to allow that to complete the full establishment of a mutation within a fixed portion of the race the necessary germinal changes must have been effected as many times as there are individuals representing the mutating portion. For where we are concerned with a numerically fixed population, a mutation of no selection value, equal fertility and opportunity for mating, conditions which seem nearly approached in the case of the wild ostrich, then, as Mr. G. H. Hardy* has shown, a mixed population falls into a stable condition of equilibrium with regard to the proportions of the two homozygous and the heterozygous forms after a single generation, and this position is thereafter maintained. A new mutation of no selection value can ordinarily increase in number in a homozygous form only for as many times as it makes its appearance *de novo.* It cannot be bred into the race, but must appear independently for each increase.

The conditions surrounding the bald patch, for example, are particularly convincing on this point. It is a mutation which has arisen in the northern race, the feathers falling out when the chicks are about three months old. It is probably altogether intrinsic in its origin, as it is in the highest degree improbable that any environmental conditions could have brought it about which would not be also effective in the case of the southern bird. Though representing an absence of feathers, experiments have proved that it is homozygous and dominant over the presence of a covering in the southern bird. It is hardly conceivable that it has any bearing on the welfare of the bird, and therefore has in no measure been influenced by natural selection. Probably it is a part of the general plumage degeneration going on in the ostrich, to be considered later. Under the conditions already postulated one or more mutated individuals could not in the end influence the race in the matter of increase; a pair in which the mutation had appeared would on an average produce only another pair of mature progeny. To establish the character throughout the members of the race, the factorial change must occur *de novo* as many times as there are individuals making up the race.

In the same manner the opening of the shell-pores in pits

* R. C. Punnett, "Mendelism," 3rd ed., London, 1911, p. 136.

in the southern birds instead of more uniformly over the surface, as in northern birds, can hardly be held to represent the slightest advantage one way or another. Whether the shell is pitted or smooth may possibly be thought to influence the respiration of the chick within, but not the slightest evidence of this is forthcoming. The northern and the southern races are equally successful, and no differences in the number or strength of the chicks at hatching are observable. The distinctive skin colours of the two are only conspicuous at the nuptial period, and in comparison with the strong plumage contrasts in the ostrich can certainly not be held to possess any adaptive significance. Whether regarded as specific or varietal, the characters seem to have arisen independently in separate continental areas, and are quite apart from any considerations connected with the welfare of the bird. Appearing in an established race, the necessary germinal changes must have recurred as often as there are individuals concerned, for, having no selection value, the new characters could not otherwise have replaced the original characters. The mutual fertility of the two races indicates that physiological isolation can have had no influence; geographical isolation has been maintained as far as concerns the more extreme parts of the continent, yet has had no influence in bringing about the changes, but only in preventing intermingling.

For a dominant repetition of similar mutations to occur it is manifest that the germinal changes involved must be removed from the realm of occurrences which are altogether fortuitous or incidental. They must be the result of some intrinsic condition common to the germ plasm of the one race as compared with that of the other, or of some uniform influence acting upon it. That germinal changes are ever of a regular recurrent nature is, however, a view wholly averse from that of mutationists of the present day. As indicated by the introductory quotation from Prof. Bateson, mutations everywhere seem to be regarded as fortuitous and isolated, dependent upon irregularities in the mitotic processes which occur between one generation and the next. Yet there appears no escape from the conclusion that the recurrent process must have been largely concerned in the establishment of specific characters generally, if we are to accept the view that most new characters are intrinsic in their origin, are rarely concerned with the welfare of the organism, and are the concern of natural selection only as regards elimination, conclusions which seem to find full confirmation in the ostrich.

In a paper entitled "The Form of Evolutionary Theory that Modern Genetical Research seems to favour," Dr. C. B. Davenport* develops the idea, already expressed by Hagedoorn, Lotsy and Bateson, that mutative changes are largely the result of the fractionation of highly complex molecules into simpler, deriving support for it from palæontology and experimental breeding, and,

* "Amer. Nat.," vol. L, Aug., 1916.

by analogy, from embryology and radiation studies. He summarizes as follows: "A theory of evolution that assumes internal changes chiefly independent of external conditions, *i.e.*, spontaneously arising, and which proceeds chiefly by a splitting up of and loss of genes from a primitively complex molecular condition of the germ plasm, seems best to meet the present state of our knowledge." Prof. Bateson* has remarked: "It is to be inferred that these fractional degradations are the consequence of irregularities in segregation."

On the view that factorial changes consist of chemical or physical changes taking place in highly complex molecules, it seems more feasible to think of them as proceeding with some degree of regularity or method in place of the irregular haphazard manner so generally accepted. Incidental changes may well occur in such an organic complexity as the factors are deemed to be, and it is probably these which have been mainly studied hitherto; but it may be that they are merely the outposts of determinate changes of a more fundamental character which the germ plasm can undergo. The former may well be frequent and in many directions, but are of small moment for purposes of evolution. More regular molecular alterations may at times be in progress, and we get the same change slowly taking place throughout all the individuals of a race possessing the same germ plasm, or, as will be sought to show later, an orderly succession of changes all in the same direction. The difficulties and uncertainties involved in an analysis of the genetic changes concerned in any continuous retrogressive or progressive change in a character are well set forth by Prof. Morgan in his article, "Evolution by Mutation," already noticed.

That transformation of a whole race can take place without natural selection being in any way concerned was recognized by Darwin. In the "Origin of Species" (6th ed., p. 27) he remarks: "There can also be no doubt that the tendency to vary in the same manner has often been so strong that all individuals of the same species have been similarly modified without the aid of any form of selection." Prof. Morgan, in his work, "Evolution and Adaptation," 1903, was also inclined to support the same view where he says (p. 293): "Equally important for the descent theory is the idea that the same mutation may appear time after time. There is good evidence to show that this really occurs, and in consequence the chances for the perpetuation of such a form are greatly increased. Delbœuf, who advocated this idea of the repeated reappearance of a new form, has also attempted to show that if this occurs the new form may become established without selection of any kind taking place—the time required depending upon the frequency with which the new form appears. This law of Delbœuf, de Vries believes, is correct from the point

* "Science," vol. XL, Aug. 28, 1914, p. 298.

of view of the mutation theory. It explains, in a very simple way, the existence of numerous species—characters that are entirely useless." And again in 1918*: "If related species have many genes in common they may be expected to produce at times the same mutants."

Prof. Bateson is, however, wholly opposed to mass or racial evolution of this character. In his Australian address (p. 301) he remarks: "Modern research lends not the smallest encouragement or sanction to the view that gradual evolution occurs by the transformation of masses of individuals, though that fancy has fixed itself on popular imagination." The broad survey which we are able to take of the ostrich, practically continental in its extent and unlimited as regards numbers, may well lead us to different conclusions. In the next section, dealing with the retrogressive mutations in the ostrich, we appear to have evidence that corresponding germinal changes have been, and are being, effected independently throughout the entire race.

Successional Mutations.

Isolated, discontinuous mutations, whether large or small, do not appear to have been the means whereby the more fundamental features of organisms have arisen. They fail to afford an explanation of the various intermediate phases of development of structures and organs which confront the comparative anatomist and palæontologist who survey wide evolutionary series. For the production of these, germinal changes of a successional cumulative nature seem to be required, continued with the same trend over long periods. The recurrence of the same mutation throughout a race would give specific or generic separation, but would not provide a sequential series in a definite direction, of which we have so many instances in the animal kingdom.

In his article, "Evolution by Mutation," Prof. Morgan sees the necessity for a successional series of changes, but regarding the matter altogether from the Mendelian aspect, has a meagre offering to make. To steer clear of any suspicion of a directive force in the germ plasm, he submits (p. 50) the following as of fundamental importance when evolution is treated merely as a phenomenon of chance: "Starting at any stage, the degree of development of any character increases the probability of further stages in the same direction. . . . In this sense evolution is more likely to take place along the lines already followed, if further advantage is to be found in that direction. . . . The individual multiplies itself, and a new mutant character that is advantageous becomes established in a large number of individuals, or even in all the individuals of the race. The number of individuals

* "The Scientific Monthly," vol. 7, July, 1918, p. 47.

increases the chance of a new random mutation along the path already taken." . This is Darwinism of the purest type, but relegating the succession of mutations to a mere matter of chance does not take us very far. "Advantage" is freely postulated as a necessity of evolution, but from the considerations to be given below it is sought to show that in the case of the ostrich, at any rate, its assistance is highly problematical.

During the last twenty years workers on mutation have apparently encountered no experimental type in which successional changes with a definite trend are in progress, so that their scepticism as to its reality can be understood, as also their efforts to make discontinuous haphazard variations the sole basis of evolution. It may be that few forms are in such a phase at the present time, or that the process is so slow as to be beyond ordinary experimental observation; but as to its actual occurrence in the past there can be no question.. There may be something in the contention of Prof. M. Caullery* that variability has not been the same in all periods, and also in the view of de Vries† that the mutative state of a species may differ at different times. In the opinion of the writer, the facts associated with the retrogressive evolution of the ostrich show that the bird is in a highly mutative state at the present time. The various degenerative stages are deemed to be explicable only on the assumption of successional germinal changes with a definite trend; moreover, as the changes appear to be wholly intrinsic in their origin, and the question of advantage seems to be in no way involved, natural selection is held to have no guiding influence, but only that of final elimination.

The African ostrich has long been regarded as a degenerate bird, mainly on account of the small size of its wings and the unique reduction of its toes to two, the third and the fourth, of which the latter is already greatly reduced in size compared with the former. Observation shows that losses have taken place in many other directions, particularly as regards the plumage, while the abundance of material available on the ostrich farms of South Africa, along with a large importation of North African birds, reveals that the losses have occurred throughout the continent and proceeded at different rates in different individuals. It is held that the various stages now met with are so much evidence of the manner according to which the losses have occurred in the past, and therefore of the manner in which the germinal changes must have proceeded.

Briefly, the main facts are as follows. In most ostriches the under surface of the wing is naked except for the presence of a single incomplete row of under-coverts. Survivals of a second and even of a third row occur very rarely, and all numerical

* "Science," vol. XLIII, April 21, 1916, p. 555.

† "Species and Varieties: Their Origin by Mutation," London, 1905, p. 699.

stages can be procured from three rows, to where as many as ten plumes are wanting from the elbow end of the single first row and four at the other end. The loss of plumes follows a regular ordinal succession; but prior to its final disappearance each plume passes through a definite series of retrogressive stages, represented by a gradual diminution in size and then loss of constituent parts. Observation shows that usually only one or two plumes at the end of a row are in a degenerative phase at the same time. The valuable remiges fluctuate from 33 to 44, diminutive or vestigial feathers sometimes occurring at the retrogressive end of the row similar to those in the rows of coverts. The first row of upper-coverts has barely started on its course of degeneration, but the second fluctuates from a complete row to one where as many as half have disappeared, and the succeeding rows in some birds are greatly reduced in length and number compared with others.

Down feathers are usually stated to be absent from the Ratitæ, but in the ostrich they are still to be found as survivals around the base of the larger plumes of the wings and tail, and individuals occur with vestigial down over the hind part of the body and even under the wings. Moreover, all stages in the loss of the individual feather, represented first by diminution and then by loss of constituent parts, are presented, similar to those exhibited by the coverts and remiges.

All intermediate stages occur in the degeneration of the second phalanx of the third digit of the wing, from a completely free bone forming a projecting free third digit to a mere nodule fused to the end of the first phalanx, and not apparent from the surface. The digit is also unique among birds, in that it occasionally bears its own plumes, like the ala spuria. Traces of four metatarsals occur in the embryo chick with a phalanx to the second reminiscent of the three-toed ancestor, and all stages can be procured in the loss of the claw from the small fourth toe, and also in the disappearance of scales from the big middle toe, showing that the latter has also started its course of degeneration. While in the main the various retrogressive stages show Mendelian proportions in breeding experiments, departures from this seem to find their interpretation in the fact that losses are actually in progress. This is particularly the case as regards the nail on the fourth toe and the scales on the third, where the progeny of crosses usually show much reduction compared with the parents. In all cases a definite succession in diminution in number or size or loss of structural parts is indicated, as compared with one haphazard or irregular, one loss preparing the way for the next, and rendering it possible.

The many breeding experiments have shown that all the variations are germinal in their origin, as distinct from somatic fluctuations. None of the birds are yet germinally pure as

regards any one of the retrogressve stages, but the results hitherto warrant the expectation that pure lines can be extracted, except in so far as degradation happens to be in progress. As regards most of the losses, it is extremely doubtful if adaptation or the welfare of the bird is in any way involved, and therefore natural selection can in no measure be held to be directing their course. It is inconceivable, for example, that the gradual loss of single plumes in an ordinal sequence from the row of under-coverts or elsewhere can have any discriminative bearing on the welfare of the bird. Moreover, the losses have proceeded, and are proceeding, on similar lines throughout the continent, showing an independence of environmental conditions, and impelling one to regard them as wholly intrinsic, presumably the result of some inherent condition of the common germ plasm of the race, or some consistent influence acting upon it.

A completed retrogression, for instance, the loss of the first and second toes, may be conceived as being of advantage to the bird in the matter of rapid locomotion; but no such consideration can be ascribed to the many intermediate stages by which the process has been effected; and yet it is by the summation of small successive changes that all the losses have been made. For example, the claw on the small fourth toe is so reduced that it never reaches the ground, and, as it is entirely functionless, its presence or absence can have no selection value. It has already disappeared from about 75 per cent. of the birds, and the various intermediate stages still remaining reveal that its loss is in progress in the comparatively few individuals in which it yet survives. On mechanical grounds an adaptive value may be accorded the retention of only the middle toe when the small fourth disappears, as in the case of the horse; but, as unquestionable evidence is forthcoming that degeneration has already begun on the third, its continuance would certainly dispel any idea that the welfare of the bird is involved. A progressive or retrogressive change may incidentally be beneficial to a certain stage, but harmful when continued further.

It has often been pointed out that for a mutative series, whether progressive or retrogressive, to be directed by natural selection step by step, it must have a welfare value from the beginning, and also at each succeeding stage; but this is altogether improbable as regards the degenerative series in the ostrich. Unless selection can be invoked we must contemplate successional internal changes, say, of the nature of a regular methodical degradation of some highly complex chemical combination, such as the factors are deemed to be, changes uninfluenced by external circumstances and without any concern for the welfare of the individual. It is suggested that the degradation may be of the nature of a slow senescence of the constituents of the germ plasm, perhaps involving the Ratitæ as an entire sub-class, for

each living and extinct representative is characterized by marked degenerative phases.

The entire argument, that the various series of degenerative stages in the ostrich represent so many orthogenetic or rectigrade evolutionary series, arising from successional cumulative factorial changes, rests upon the acceptance of their sequential nature in determinate directions. Do the many survivals correspond in a general way with the order of succession of the losses between two extremes, or are they so many haphazard variations which have arisen, apart from any which have gone before, or which will come after? Only by establishing this can we justify their claim to be so many evolutionary series, and to demand the attention of Mendelians as varietal somatic expressions which call for interpretation in factorial terms.

Among the large number of individual birds, the possibility of securing for each degenerative trend a continuous series of stages between the extremes admits of no question, even though it is held that each has arisen as a discrete factorial change. It has, however, been pointed out by Galton and others that a continuous series of intermediate variations between two extremes does not necessarily represent a germinally successive series, nor indicate an evolutionary trend. Thus Morgan has shown that in *Drosophila* it is possible to arrange a continuous, graded series of eye-colours from one extreme to the other, and also a similar series with perfectly formed wings at one extreme, and no wings at the other. Yet observation shows that the different mutations, however small, appear quite independently one of another, not in any regular succession, and large steps occur as well as small ones. They do not represent a cumulative series, and apparently are not concerned with either progressive or retrogressive evolution of the fruit fly. All grades in human skin colour could be procured from the black of the Negro to the white of the European, yet no one would dream of regarding them as a successional genetic series.

In a paper, "Genetics *versus* Palæontology," Dr. W. K. Gregory* has fully discussed the evolutionary value of intermediate series of fossil stages, contending "that the palæontologist is dealing with truly successive stages, and not with an arbitrarily selected series of mutants." Where a continuous series of intermediates between two extremes can be shown to be associated with a definite evolutionary trend, the various steps may with good reason be accepted as representing, in a general way, at any rate, the successional stages in the transformation of the particular structure. Thus no one disputes that the palæontological series extending from the ancestral pentadactyle foot to the single toe of the modern horse represents, in a general way, the successive retrogressive stages through which the

* "American Naturalist," vol. 51, Oct., 1917.

evolution of the foot of the horse has taken place, and that corresponding successional changes must have been undergone by the germ plasm. The series revealing the increase in size and complexity of the teeth, so clearly shown in Gregory's paper, would presumably be acceptable to all as a successional cumulative series, revealing the orthogenic nature of the evolution of the teeth of the modern horse, and also calling for germinal changes of a corresponding nature.

The claim for the successional nature of the different retrogressive series in the ostrich is even more insistent, from the great number of individual northern and southern birds available for observation along with complete embryonic stages. In every case an evolutionary retrogressive trend is indicated when comparison is made with other birds. The gradual ordinal loss from the rows of under- and upper-coverts and remiges, each plume in piecemeal stages; the slow disappearance of the down, each member also in piecemeal fashion; the continued stages in the reduction of certain of the digits of the wing, and especially of the foot, all indicate a definite determinate trend, and can only be the somatic manifestation of continued, determinate factorial changes in the germ plasm of the ostrich. Each germinal loss or alteration is held to be discrete, and each renders the next one in the series possible; nothing fortuitous or irregular in the order in which they proceed has been encountered.

The degenerative changes are of the same character throughout the race, for corresponding stages are found in both northern and southern birds, and may, therefore, be presumed to be the same throughout the continent. Individual differences occur, indicating the different rate at which the changes take place, affording the data as to the manner in which they are proceeding, but nowhere is there any suggestion of a divergent trend; the direction of each series is constant throughout. It is this continental uniformity of the losses which is so strongly suggestive of the intrinsic nature of the germinal changes involved, and of the absence of any adaptive consideration. The germ plasm throughout the race must have undergone, and be still undergoing similar degradation changes, and though of their true nature we know nothing, they can only be conceived as regular and methodical.

The losses in the ostrich are proceeding with such regularity and in such definite directions that there need be no hesitation in predicting their course in the future. Thus the single row of under-coverts may well be expected wholly to disappear, following upon the loss already of at least fourteen of its members, and that of the second and third rows. The upper-coverts are greatly reduced in some birds, and, along with the remiges, may be expected to follow the way of the under-coverts. There can be no question that the already reduced fourth toe will, in process of time, leave the ostrich with only

the single middle toe, and, although this may for the time being incidentally result in some mechanical advantage to the bird in running, evidence is afforded that the retrogressive force will not stop here. Could we conceive of the ostrich surviving long enough, there need be no doubt that it would ultimately suffer the loss of all its toes as well as its plumage. In the end natural selection is powerless against the degenerative influences at work in or on the germ plasm; it cannot stay them indefinitely, nor can it direct them; it can only eliminate when the stages have proceeded so far as seriously to interfere with the welfare of the bird. The ostrich appears to be a forcible illustration of the remark by Dr. M. M. Metcalf*: "Natural selection has consisted largely in the elimination of species whose unfitness was shown only after a long period of indifferent orthogenic development."

Elimination by natural selection will not be simultaneous for the race, but will be largely determined by the individual rate of retrogression. It will at first concern those particular individuals in which retrogression had proceeded furthest, but in time the extinction stage will be reached by others, and ultimately by the entire race. A course of degeneration entered upon need not, however, necessarily be completed before a halt is made, as is here assumed. Thus the modern horse, which ancestrally has lost four of its digits, seems to afford every proof that retrogression in this particular direction has now ceased, and that no fear need be entertained that it will ultimately lose its remaining middle toe, as would be the case if degeneration proceeded consistently. The vestigial survivals of the hind limbs and girdles in the boas and pythons among snakes, and also among cetaceans and sirenians, may either indicate a cessation of the original degenerative influence, or they may represent instances in which retrogression has proceeded more slowly than in related forms, and in which further losses will yet take place. Similarly with the human ear and scalp muscles and the vermiform appendix: their persistence in varying degrees may either indicate a cessation of degeneration, or the last survivals of structures the loss of which will yet be completed.

That the degenerative stages presented by the ostrich at the present day justify us in making predictions of the above nature, as well as others which could be mentioned, should suffice to establish the claim that the losses are truly orthogenetic or rectigrade. They have been real in the past for ages and ages, and no reason whatever exists for thinking the same trends will not be maintained in the future. Instead of being satisfied with casual, seemingly fortuitous factorial changes, the Mendelian has to face the bigger issues of continued, cumulative changes in many directions, common to the germ plasm of a whole race.

* "Journ. of Heredity," vol. VII., Aug., 1916, p. 357.

In a paper, "The Trend of Genetics," Dr. A. F. Shull* asks the pertinent questions: "If a gene is altered in a given way to-day, is it likely to be further altered to-morrow; and especially is it more likely to be further altered again in the same direction than in any other way? . . . Can the direction of spontaneous alteration be predicted?" Probably all will admit that the somatic expressions of degeneration in the ostrich are so much evidence of genetic change, and as, with good reason, predictions for the future can be made, this may certainly be accepted as an affirmative answer to the questions proposed.

SUMMARY.

The conditions encountered in the ostrich appear to call for mutative germinal changes of three types:

(*a*) Fortuitous, disconnected mutations in numerous directions which provide the small hereditary characters distinguishing the various individuals or strains; especially noticeable among the plumes, which have been studied intensively, and show an almost infinity of germinal variations within prescribed limits. They are the haphazard factorial changes presumed to result from mitotic irregularities during gametogenesis. Any of the variations incidentally conferring an advantage over the others would become subject to natural selection, and the result would be a preponderance of the individuals possessing them; but they are manifestly too insignificant to count in the large issues involved in the struggle for existence. They have probably no influence on the evolution of the ostrich.

(*b*) Recurrent, discontinuous changes of the same factor or factors, gradually affecting all the members of some restricted portion of the race; especially exemplified by the well-marked distinctions between the northern and southern birds, as regards baldness, dimensions, colour, and the nature of the egg-shell. Presumably they are the result of isolated factorial changes due to some intrinsic condition of the germ plasm of a part of the race, or to some uniform influence acting upon it. Incidentally, they may confer an advantage, but it is highly questionable; they would afford specific evolution apart from any selection value.

(*c*) Regular, successional changes in definite directions throughout the race, giving the various intermediate stages in several retrogressive orthogenetic or rectigrade series; the stages reached at any one time varying somewhat in the different individuals, showing they proceed with a measure of independence both as regards any particular individual and any particular trend. Exemplified in the ordinal succession of losses from the under- and upper-coverts and remiges, the down, and the digits of the wing and foot. Presumably they are the result of some orderly, continued factorial degradation or loss in the germ plasm.

* 20th Mich. Acad. Sci. Rept., 1918.

All the mutative changes appear to be wholly intrinsic in their origin and independent of any environmental influence; the characters resulting are deemed to have no adaptive or welfare value, beyond those of a purely incidental and temporary nature; natural selection is held to have no directive influence, but will be eliminative when retrogression has proceeded so far as to interfere with the necessary activities of the bird.

INHERITANCE OF CALLOSITIES IN THE OSTRICH.

By Prof. J. E. Duerden, M.Sc., Ph.D.

(*Abstract.*)

Read July 10, 1919.

Apart from the strong callosities on its feet and ankles, the ostrich has two conspicuous, thickened pads over the parts of the body upon which it rests when crouching, namely, one over the rounded projecting sternum in front and another over the pubic symphysis behind. They present the appearance of hard, rough thickenings of the skin, manifestly formed as adaptations to the pressure and friction to which the two projections are subject when the bird crouches on the ground or rolls from side to side. They afford a strong contrast to the surrounding smooth skin, and there is no question that they could be formed naturally as a result of the habits and activities of the bird, in the same manner as callous thickenings are developed on the human hand as a result of manual labour.

It is found, however, that the callosities occur over the sternum and pubis of the ostrich chick prior to hatching, and are consequently to be regarded as hereditary structures. We have, therefore, a hereditary character of a form and nature exactly similar to one which would otherwise be acquired independently from the known habits of the ostrich and the established responsive nature of its skin. The same structure has a germinal origin, and could also be produced in the course of the life-time. It is hardly conceivable that a change could have occurred independently in the germ plasm of such a nature as to give rise to a somatic character, having exactly the same nature and situated in the same place as one which would be naturally produced from the activities of the organisms, and it is contended that the chick callosities can only be interpreted as instances of acquired characters which have in some manner become transmissible. Natural selection can have no guiding influence, for, even if not transmissible, the thickenings would arise as needed, just as they do on the human hands.

In support of such a heterodox view, it is submitted that a character may become transmissible without necessarily being germinal, in the sense of having factorial representation in the germ plasm. Acquired characters are somatic modifications which are produced as responses of the organs and tissues to stimuli from the environment or from use and disuse, and reveal an inherent power of responsive adaptability in organisms. It is suggested that where responses are continued generation after generation, as in the case of the callosities of the ostrich, they may, as a result of the structural inter-relationships established, gradually appear earlier and earlier in the ontogeny of the individual and independently of the primary stimuli, and in time come to be formed prior to hatching. They may become transmissible characters without necessarily being germinal, that is, without having distinct factorial representation.

On a hypothetical conception of this kind, it may be understood that the continued production of sternal and pubic callosities has introduced such fixed and intimate inter-relationships of the structural parts concerned that in the end they come to replace the old inter-relationships altogether, and with them the non-callous state. The callosities are formed antecedent to and apart from the primary stimuli. Their appearance becomes accelerated, as it were, and they arise even before the chick is hatched and the original stimuli can be effective. They are not new characters which have come in, but are new as regards the ontogenetic time at which they appear.

While the body of the crouching ostrich is mainly supported upon the median sternal and pubic callosities, it is steadied laterally by the ankles and feet, and these show strong thickened pads which are also hereditary. Usually, however, an accessory pad forms on the inner side of that at the ankle, and the bird rests upon this acquired thickening instead of upon the hereditary one. Manifestly some modification in the crouching habit of the ostrich has taken place, since it no longer uses its hereditary ankle callosity, but forms a new one. It is suggested that the original callosity was functional when the ostrich was at the three-toed stage of its evolutionary history, and that since the degeneration of the inner (second) toe a new support has become necessary on mechanical grounds. The original callosity is hereditary and non-functional, while a new functional callosity takes its place, but is non-hereditable.

PSYCHICAL RESEARCH.

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Read July 10, 1919.

The subject of psychical research is too vast and as yet too little advanced to admit of any but a very meagre and general statement, especially by one who has only begun anything like a systematic study of the special problems which it involves. What follows must be taken as a first and very tentative presentation of this large and difficult subject. It will state an attitude more than a conclusion; and it will concern itself with hypotheses rather than established results.

The first thing we have to get clear about is that psychical research is as fit and genuine a field of scientific inquiry as any other. Science and scientific method cannot be restricted to spheres in which definite results have already been attained, or to spheres which lend themselves more readily than others to the attainment of such results. Fortunately, men of science, after for long treating the subject with disdain or with contumely, have begun to see that there is warrant for the bestowal of the same open-mindedness, the same patient and thorough research, on the psychic as on the physical aspects of existence. Any other attitude than this, however much it masquerades in the name of science, is not scientific, but entirely unscientific.

Properly speaking, the term "psychical" or "psychic phenomena" should be coextensive with mental states or processes in general. But it—as well as the corresponding term "psychical research"—has come to be used to denote not the ordinary or normal manifestations of consciousness, such as the exercise of the five senses and of thought, volition, etc., as based upon these, but phenomena that are, in the literal sense of the word, *extra*ordinary, *i.e.,* out of the usual or different from habitual and therefore generally recognized workings of the mental life. At all ages in human history there have been records or traditions of experiences that went beyond the impressions of the recognized "five senses." But it is, speaking generally, only within the last half-century that such experiences have been made the subject of any thorough and systematic investigation. I shall first give a survey of the ground* and state

* In the delivery of this paper the different types of phenomena were illustrated by examples, quoted chiefly from Barrett, "Psychical Research" and "On the Threshold of the Unseen," and Podmore, "Naturalisation of the Supernatural." Many of the cases cited by these authors are transcribed from the *Proceedings* or the unpublished *Journal of the Society for Psychical Research,* and my aim was in every instance to choose examples that were well-authenticated as facts, whatever might be the explanation which they required.

the hypotheses suggested by psychic occurrences of various kinds, and shall then add one or two reflections on the general interpretation that is to be put upon the phenomena.

The simplest and least dubitable of such supernormal phenomena are afforded in what is known as thought-reading. Here the result is simply due to unconscious muscular guidance of the subject or percipient by the agent. That is, the percipient or thought-reader consciously or unconsciously interprets muscular movements imperceptible to the ordinary senses that are made unwittingly by the agent as the expression of what he has in mind. There is no reason to doubt that such motor automatism is sufficient to account for the facts. Thought-reading of this kind is therefore, as it is aptly called, muscle-reading. It has been shown by the well-known psychologist, Professor Jastrow—following up early suggestions and experiments of James Braid and Faraday—that there is a constant tendency to make slight automatic movements of the hand, the head, the body in the direction of, or in accordance with, the object of which one is thinking. This is the physiological basis not only of thought-reading, but of table-turning, of rappings, of automatic drawing and writing. Whatever else there is in psychic phenomena, there is unquestionable evidence that the normal course of consciousness may be accompanied or even interrupted by unconscious processes expressing themselves in movements (including utterance) that seem to the agent, when he is made aware of them, to be independent of his own "self" altogether. The more such automatism is developed by neuropathic conditions, by habit, or by training, the more there is a dissociation of oneself into different strains that may become relatively independent of each other. In normal individuals under ordinary circumstances automatic action of this kind is habitually controlled or even suppressed, and therefore cannot develop beyond certain limits. But there seems no doubt that mediumship, for example, is, in one aspect at least, interpretable as merely an exaggerated form of automatism with its attendant disunion of personality.

A step further than thought-reading under unconscious muscular guidance is thought-transference in which muscular guidance cannot be the only factor involved. This may occur either with or without contact between the percipient and the agent. Colours, drawings, imaginary objects or scenes, numbers, tastes, pains, etc., can be transferred to a subject who is susceptible enough to receive them. It has long been known that the susceptibility to suggestion is especially great when the subject is in a hypnotic state. Hypnotism as an art, or as an aid in medical practice, is the deliberate and methodical use of the fact that in a condition of unconsciousness a person is open to suggestion in a way that the ordinary consciousness makes impossible. This treatment by suggestion is due, firstly, to the fact

that the hypnotic state is one of anæsthesia or absence of sensation; and secondly, to the fact that the suggestion given by the operator liberates the subconscious, recuperative, and formative forces within the organism of the patient. It is simply a case of making conscious and purposive use of conditions that are ever present, although hidden and inoperative until they can be got to work effectively. But such thought-transference or suggestion is independent of hypnotic conditions. Given a sufficiently sensitive subject, it is equally possible in the normal state of the percipient. Cases of this kind have been investigated, under test conditions, absolutely excluding chance or collusion, leaving no alternative to the conclusion that by some individuals, at least, mental impressions can be received by other than the ordinary avenues of sense. In dealing with this class of phenomena the great difficulty is to be sure that they may not be the result of hyperæsthesia, *i.e.*, a heightened or enlivened exercise of the senses of touch, sight, or hearing, which is especially characteristic of the hypnotic state—in particular, to the perception of unconscious and almost imperceptible indications given by the voice, look, gestures, or breathing of the experimenter or agent. But, when due allowance is made for this, there still remains evidence for a mode of communication other than the recognized sensory channels. This does not mean that there is nothing of a sensory or impressional character in the reception of the suggestion—all analogy points to the opposite conclusion—but only that hyperæsthesia of the ordinary senses does not explain all the facts. Some other mode of impression has to be postulated.

It is again but a step, therefore, from thought-transference of this kind to telepathy as ordinarily understood, *i.e.,* literally, feeling or impression at a distance. This term was suggested by Frederic Myers to cover all cases of thought-transference where there is no contact of the percipient with the agent; but it is more commonly confined to thought-transference over longer distances. There is an abundance of data which suggest that the occurrence of some idea or of some event to one person may be transmitted, either spontaneously or intentionally, as a thought or impression to another person at a greater or less distance away. Here again a passive state in the percipient is specially favourable to the reception of a communication or impression; and in the case of intentional or experimental communication, it is found that the best results are obtained when no special effort is made by the transmittor to communicate an idea, but the underlying intention is allowed simply to operate, so to say, at its own time and in its own way.

Two points require to be specially noted in this connection. In the first place, no single illustration will ever be found that affords, by itself, conclusive evidence of the existence of telepathy. Any single occurrence may be a chance coincidence;

may be concocted or misreported or misinterpreted. To wait for a single conclusive instance, either for or against telepathy, is to wait for the impossible. The only method is to weigh the accumulated evidence. When this is done, it will be found that the case for telepathy, as a hypothesis required to express at least provisionally the nature of a vast number of occurrences, whose authority as bare facts is beyond all reasonable doubt, has been quite sufficiently made out. The explanation of the occurrences in the sense of the laws of the actual working of the mode of communication concerned, or its precise definition and its relation to known modes of communication, is still wanting. But the *onus* now lies on objectors to formulate a hypothesis that is anything like equally adequate to the facts. In the second place, it is necessary to emphasize that it is not the conscious but the subconscious factors of our mental life that are most effective in the transmission and reception of telepathic impressions. It is not mere volition as a deliberate process so much as deep-lying interest and sympathy that counts in the occurrence.

If we accept the evidence for telepathetic transmission as sufficiently strong to constitute telepathy a *vera causa*, the difficulty then becomes to decide how far all supernormal psychical phenomena are to be explained as instances of telepathic impression without the need of any further hypothesis, such as a faculty of precognition or the survival of bodily death, to account for them. Just as the simplest and most indubitable principle, namely, that of motor automatism or unconscious muscular guidance, must be used to explain all cases that require nothing further than this, so telepathy, apart, in the first instance, from any theory of the mode of transmission implied, is the form of explanation that must be used wherever possible, namely, that some other mind is, whether consciously or unconsciously, impressing upon the subject of psychic phenomena ideas and experiences which are interpreted as though they were, for example, messages from departed spirits or manifestations of supernormal intelligence.

We may pass now to the next set of phenomena, those of clairvoyance, or, as it is termed in Scotland, second-sight. Investigation of the distinctive phenomena of dreams or the dream-state belongs to general psychology, and dream interpretation forms a particular branch of psychological analysis; but there are dream experiences that have a relation to the special problems of psychical research. These are dreams in which there are not only dream pictures, but apparently a supernormal percipience or clairvoyance wherein the individual perceives facts that are beyond the range of ordinary apprehension. The most typical are the numerous cases where lost articles have been found through their being visualized in their place of concealment, in a dream. Allowing for the possible explanation of some cases by the emergence during sleep of a memory too faint

to assert itself in the waking state—a memory of the conscious or subconscious perception of the lost article by ordinary vision, or again by telepathic reception of the fact from some other person, there still remain cases that seem inexplicable on any simpler hypothesis than that of telæsthesia, that is, perception at a distance. Such dreams therefore introduce the general subject of clairvoyance. Here, again, the natural starting-point is the fact that hypnosis, which may be regarded as a particular form of sleep, is specially favourable to perception of a supernormal kind. The main condition of all such phenomena is found in complete detachment from normal sensory impressions. What is called crystal-gazing is nothing but the use of one specially helpful means of inducing incipient hypnosis and thereby getting visions or appearances of some sort which transcend ordinary sense perception. But the phenomena concerned are independent not only of the dream-state, but of hypnotic conditions, and also of the use of crystals or any similar inducing agent.

It seems to me to be an altogether undue strain on the telepathic hypothesis to make it cover all cases under this head.* The hypothesis of chance is still less adequate. As already said, any single instance may be set down to chance—that is, may be regarded as a mere coincidence of occurrences, though the odds against events of this kind being the result of chance have been calculated to be as many as a million, sometimes hundreds of millions, to one. With regard to the hypothesis of telepathy, the point to be noted is that cases of prevision or precognition, that is, dreams or the like in which future events have been foretold, though not perhaps authenticated in sufficient number and with sufficient evidence to give an indubitable conclusion, are clearly, if established, inexplicable by telepathy alone. It may be added here that what is called dowsing, that is, the locating of water, metals, etc., is so far the same as clairvoyance that it seems to imply the possession of a supernormal perceptive power which enables detection of the hidden object, and which expresses itself in an involuntary muscular tremor akin to the unconscious muscular movement by which thought-reading is made possible.

The last set of subjects are those connected with the hypothesis of survival after bodily death and communication with the unseen world. The phenomena concerned fall mainly under the two heads of—(1) hauntings and kindred apparitions; (2) messages delivered through trance and automatism. By haunting is usually meant the appearance, at different times and to different people, but in the same locality, of a quasi-human form resembling in various particulars some deceased person. Various

* Some of Podmore's explanations, for example, are ingenious rather than convincing (see *Naturalisation of the Supernatural*, pp. 92, 343, 354-7).

explanations have been suggested for such appearances. The easiest hypothesis is that the appearance is only a hallucination or mental projection of the percipient without any objective basis. But the influence of locality, that is, the fact that the apparition comes to different persons in a particular spot or neighbourhood, requires to be accounted for in some further way. On the hypothesis that such apparitions are hallucinations produced in the percipient by some telepathic impression from the deceased person, the suggestion has been made that the local character of the apparition may be explained by the occupation of the consciousness of the percipient in present sensation with the same set of objects as those which occupy the memory of the agent. Another hypothesis is that the explanation of the appearance is to be found not in a continuing local interest on the part of the deceased person, but in the existence of some kind of local imprint left by an event or events in the life of the deceased and perceptible under certain conditions by appropriately sensitive subjects. Such an imprint would be somewhat analogous to that left on a pane of glass by a coin and made perceptible by breathing on the glass, or by anything laid on a photographic plate and perceptible when the plate is developed, and analogous also to the influence that is found to have been made on things over which a hypnotizer's hand has passed. Even if such appearances are hallucinatory in the sense of being projections from the mind of the percipient, this does not imply that they are void of all objective foundation or reality. For all objects as we actually perceive them are phenomena or projections of our own minds, not transcripts of the real nature of things.

As regards the general question of survival and the evidence for it adducible from psychical research, we may start from the unquestionable facts, first, that one person may voluntarily convey a phantasm or appearance of himself to another person at a distance, and secondly, that at the moment of death an apparition of the dying person may come to another, to whom presumably there has been some intense reference in the dying person's thoughts or to whom at any rate the death is for some reason or another of peculiar or tragic interest. Of the former phenomenon there are several well-authenticated cases. Such appearances, therefore, come under the head of veridical or truth-telling hallucination, that is, a mental image coinciding with some distant real occurrence; and are instances of telepathic communication, whether of the voluntary or the involuntary kind.

For the latter phenomenon, that is, an apparition occurring about the time of death, there exists a great abundance of evidence. Here, again, there is often no need to go beyond the hypothesis of terrene telepathy, that is, thought-transference from the living, for an explanation of the occurrences. But

there are phenomena that suggest the continuation of existence after bodily death and communication between the (so-called) dead and the living. The evidence is, as yet, meagre and problematic. But there is enough of it to warrant the hypothesis of survival and the testing of this hypothesis by every resource and with all the courage and sympathy, albeit, too, with all the patience and impartiality, that can be brought to bear on the subject. What the evidence suggests is that personality or individuality persists, though still under conditions (in this respect just like the conditions of our present life) which permit of only an incomplete expression of oneself and present a very great difficulty of communicating in more than the vaguest and most fragmentary way with those who are on a different plane of life and action.

This is an aspect of psychical research which, even more than others, is still in a too rudimentary stage for any definite conclusions. Investigators are in doubt as to how far the supposed messages delivered in automatic writing or speech are to be attributed to telepathic impress from the consciousness or subconsciousness of the sitter, how far to the subconscious resources of the medium, and how far they require the hypothesis of spirit communication to account for them. The phenomena of cross-correspondence, as exhibited in the scripts or utterances of different psychics, are suggestive, but as yet slight and inconclusive. The whole subject is one that must be approached not with mere curiosity or self-interest, but in a spirit of reverent inquiry.

I pass now to a very few reflections concerning the interpretation that is to be put on the foregoing phenomena and the hypotheses suggested by them. One thing that seems beyond question is that our conscious selves are but a fragment of the mental or spiritual life that is hidden within us but may, under appropriate conditions, manifest itself. This is seen in the occurrence of impressions which, although too weak or too little heeded to arouse conscious perception, emerge into consciousness during sleep or hypnosis or even through sufficient quiescence and absence of other impressions in the waking state. It is seen again in the mental processes, of a higher order than the normal, exhibited in the hypnotic state, in genius and the like, in telepathic impressions of any kind, and indeed in psychism generally. Much that has been attributed to supernatural agency can be explained as the working or the expression of the subconscious or subliminal self.

Another point that is important is that, although these phenomena are supernormal or supernatural in the sense of lying outside the range of our ordinary experience and being inexplicable by definitely established laws of nature, we must not regard them as discontinuous with habitual experience or as not being explicable by any extension of our present knowledge. Moreover, we must avoid the common error of speaking loosely

about spiritualistic phenomena, disembodied spirits, and the like, in a way that implies independence of all material conditions. Like all our experience, this, too, requires some means or instrument of conveyance and expression, and has therefore its physical as well as its psychical aspect. Telepathy, for example, is almost, if not quite, certainly interpretable as the transmission of impressions from one brain to another by means of ethereal vibrations. This does not mean that the material or physical is ultimately different from the mental or psychical, but only that supernormal psychical phenomena, like all others, have objective conditions and a relatively mechanical aspect that will be found capable of being stated in terms of law or tendency.

The same consideration helps to explain the place of the medium in psychic phenomena. The medium plays the part of the automatist, that is, the sufficiently passive and at the same time sufficiently sensitive subject who is the instrument of transmission or communication. The limitations of the medium, not only as regards passivity and sensitivity, but also as regards mental equipment and individual character, form one of the obstacles or impediments of communication and expression. In other words, just as the individual bodily organization is, in our habitual experience, a condition limiting the influences that reach the individual (and just as thought requires language, whether speech or gesture, as a vehicle for its expression), so it is in psychic phenomena, and equally whether there is a living medium or not. The living medium or automatist is simply the highest form of autoscope, that is, the instrument of the expression of psychophysical processes that are too deep-lying for manifestation by the ordinary channels of sense. The so-called magic pendulum, the forked twig or other instrument used in dowsing, the planchette, the crystal, the thought-reader, the hypnotic subject, the medium or psychic, entranced or not, are all so many forms of autoscope or automaton which enable the manifestation of psychic activities too deep for the ordinary avenues of expression and communication. Or, to bring the matter still more into relation with the recognized conditions of our normal physical world, just as the microscope and telescope enable us to see what is otherwise unseen in the physical world around us, or as the photographic plate or the thermoscope render visible rays of light that are otherwise invisible, so the autoscope, animate or inanimate, is, in general, the condition of those glimpses into the unseen psychic world that is ever about us.

With regard to the difficult question of survival, my own view has long been that here, too, we get the best clue to the mystery by following up the suggestions of our actual experience. We know the soul or self, whether our own or that of others, only in part and only through the medium of bodily impression and expression of some kind. What psychical research suggests is the survival of personality beyond the present life under con-

ditions that are akin to and continuous with the present, although on a further plane of existence.

Lastly, the whole subject is complicated and prejudiced by erroneous ideas about the relation between mind and body and about the meaning of existence on another plane. People are so used to the abstractions of "body" and "spirit" and to the opposition of "this life" and "the future life" that it is almost impossible to mention these terms without suggesting conceptions that perforce preclude a true interpretation of the facts. Not until we realize that body and spirit are not the complete opposites that they are commonly supposed to be, but are inseparable aspects of experience, as necessary to each other as subject and object or as thought and language, are we in a position to understand the meaning either of telepathy or of survival. For if body and spirit are truly counterparts or complements of each other in any experience of which we can definitely conceive, on whatever plane of existence it is lived, then by telepathy and survival we do not imply anything that is spiritual without being also material; anything that is purely mental or psychical without a discoverable and recognizable bodily aspect or mode of expression. Similarly, the whole conception of life after death and of communication with the unseen is void of real content, for want of relation to our actual experience, until we recognize that the so-called other world is not a distant sphere or realm, but is simply a state of deeper and fuller experience, that is, a further realization of the one world or the one life in which all life participates in its own way and degree. What we call our world is nothing but the objective aspect of our individual experience, our mode of apprehension of the one reality that is present here and now, and which has for us this form or that according to the level on which our life is lived or our realization of things is sustained.

A SHORT DESCRIPTION OF THE PUBLIC WORKS AND WATERWORKS OF EAST LONDON

By J. Powell, M.Inst.M.&C.E.

Read July 10, 1919.

Historical.

East London was so named by Sir Harry Smith, in the late forties of the last century (I believe 1846), at a parade of troops on what we now call the West Bank.

The late Mr. John Arnold, of the 6th Regiment, father of Mr. James Arnold, of Arnoldton, and other well-known Border farmers, told me about 20 years ago that he well remembered being on parade on the West Bank when they were being reviewed by the late Sir Harry Smith. He (Sir Harry Smith) told them that he knew this would become a big place one day; he would therefore call it London in the East. The river was called the Buffalo River because one of their officers, a Captain Roper, shot a buffalo on its banks.

I gather from a list of titles of land in the proclaimed limits of the municipality, now in the possession of the Council, which was examined and found to be correct on the 15th September, 1884, by Mr. C. Newman Thomas, of the Surveyor-General's Office, that the first lots of ground were alienated in the village of East London West on the 17th December, 1849. The name of the first grantee appearing in the list is that of a Mr. J. Thackeray, the lot being No. 3. The east bank of the river was named Panmuir, after the then Secretary of State for War. The first lots granted appear to have been in 1858, the name of the first grantee being S. Stanger, and the lot granted No. 4 of Block O. The first reference that I have seen to the municipality is in the list of titles referred to, from which it would appear that Lot 5, Block B, was granted to it (the municipality) on the 11th October, 1876.

The municipality was incorporated under Act No. 23 of 1880, which was amended by Acts No. 12 of 1881 and No. 11 of 1895. It was brought under the General Municipal Ordinance No. 10 of 1912 by an enabling Ordinance, No. 18 of 1914. The first Mayor was Mr. Richard Walker, the first Town Clerk Mr. J. Pooley, and the first Town Engineer Mr. G. F. Newsam.

The whole area of the municipality, including the Buffalo River and the Harbour Reserve, as incorporated under Act No. 23 of 1880, was 7,945.11 acres. (The area of the Harbour Reserve is 212 acres.) There has since been added to this the demarcated forest reserve known as Bat's Cave Land, in

extent 431.3967 acres (the date of the title is December, 1902), making the total area of the municipality now 8,376.5067 acres.

The first Mayor's Minute which I have seen is that of the late Mr. Alfred Webb, dated February 29, 1884. According to the statements incorporated in this Minute, the general revenue amounted to £7,132 11s. 2d., and the expenditure was £6,845 12s., as against a general revenue for the year ended 1918 of £77,042 4s. 3d., and an expenditure of £83,560 6s. 9d.

The highest elevation is about 400 feet. The actual level of Hie's Kraal, which is on the boundary of the municipality, on the Orange Grove Road, is given by the Surveyor-General to be 415.4 feet.

Roads and Bridges.

The following is a table showing the mileage of streets, footpaths, etc., constructed by the municipality, to the end of 1918:—

	Miles.
1. *Length of streets*—	
Wholly constructed	42.3237
Partly constructed	0.4523
On which no construction work has been done	4.6250
Total	47.4010
2. *Length of kerbing and guttering*	56.8918
3. *Length of footpaths*	58.1344
4. *Number of bridges and culverts*—	
(*a*) Bridges for general traffic	7
(*b*) Footbridges	1
(*c*) Culverts (approx.)	255

Besides the foregoing, there are 5.303 miles of roads in the municipality maintained by the Divisional Council.

Waterworks.

Historical.—The first waterworks established in East London were commenced in 1883, and completed in 1885. The scheme, which appears to have been adopted at a meeting of ratepayers held in the store of Mr. C. E. Bain, formerly Messrs. Bain, Webb and Co., at the corner of Terminus Street and Cambridge Street, now the property of Messrs. Baker, King and Co., on Wednesday, the 11th February, 1880, was designed by Mr. J. G. Gamble, the Government hydraulic engineer. The surveys were made by the late Mr. A. E. Murray, and the scheme was carried out by the then Town Engineer, Mr. Geo. F. Newsam.

The scheme comprised the construction of an impounding reservoir of a capacity, in round figures, of 97,000,000 gallons on the Amalinda River, the laying of a 5-inch pipe conduit from

Amalinda to filters, and a service reservoir of 100,000 gallons capacity, which were constructed on the high ground in the vicinity of the East Bank Location. The pipe conduit was designed to deliver 120,000 gallons per day. This scheme supplied the town until 1897. Incidentally, it is interesting to note that Mr. Gamble, in his first report, dated 30th August, 1878, mentioned that although the Government had consented to his advising the Town Council some years previously, he had been unable to do so, among other things, on account of the Kaffir War.

Augmentation Scheme, 1897.—A new 8-inch C.I. pipe conduit was laid from the Amalinda Reservoir to new filter beds and service reservoirs situated at the top of Oxford Street in 1897.

These filter beds are three in number, each 48 ft. by 48 ft., and the service reservoirs have a capacity of 325,000 gallons each.

These works were carried out by Messrs. Tate and Robertson under the writer.

First Buffalo River Pumping Scheme.—This scheme was carried out in 1899. On account of the non-delivery of a pump to discharge the water direct into the Amalinda Reservoir, two pumps had to be purchased locally. The head was divided, and one pump raised the water from the first pumping station established on the Buffalo River to a second pumping station on the hill in the vicinity of the Divisional Council road. The water was delivered from this pumping station directly into the Amalinda Reservoir. The capacity of these pumps was 288,000 gallons per day of 24 hours.

So soon as the pump originally ordered arrived, it was installed, and the water delivered direct from the first pumping station into the Amalinda Reservoir. The capacity of this pump was 360,000 gallons per day of 24 hours.

The first pumping stations were opened by Captain W. E. Jackson on the 24th April, 1899. Direct pumping was commenced on the 11th July, 1899. The rising main comprised 4,000 feet of 6-inch pipes and 6,500 feet of 5-inch pipes. The latter pipes were part of the original supply main from Amalinda to East London, which had been lifted subsequent to the laying down of the new conduit in 1897.

This scheme was designed and carried out by the writer.

A new 5-inch rising main was laid from the first pumping station to the Amalinda Reservoir in 1901. This work was carried out by the then Town Engineer, Mr. W. A. Palliser.

Second Buffalo River Pumping Scheme and New 12-inch Pipe Conduit from Amalinda to East London.—This scheme was carried out in 1905. It comprised the putting down of a new triple expansion condensing pumping engine, capable of delivering 840,000 gallons per day of 24 hours, the laying of a new 12-inch rising main, and the laying of a new 12-inch pipe

conduit from Amalinda to the filters and service reservoirs at Southernwood. This scheme was designed and carried out under the direction of Mr. Charles Anthony, through the intervention of two contractors, Messrs. R. Perry and H. C. Webb.

With the exception of the augmentation of the filtration plant by the installation of a Candy's filter in 1913, no further additions have been made to the water supply of the town since 1905. The reticulation system was extended to the west bank of the river in 1913.

Other Schemes.—The Town Council obtained authority to carry out a gravitation scheme from the Buffalo River in 1899. This scheme was estimated to deliver 1,250,000 gallons per day of 24 hours, and to cost £110,000. It was designed by the writer.

Further, the Council obtained in 1906 parliamentary powers to carry out the Wolf section of the Wolf-Gulu scheme. The scheme, which was designed by Mr. Charles Anthony, was estimated to deliver 1,500,000 gallons per day of 24 hours, and to cost £320,000.

New Scheme.—The new pumping scheme, which was inaugurated on December 15, 1917, comprises the construction of a new pumping station alongside the Buffalo River on Farm No. 315, the property of Captain A. C. Wilson and the late General Brabant, and the putting down of a new pumping plant, of a capacity of at least 2,304,000 gallons per day. The water will be discharged through a 20-inch rising main into the new reservoir of, in round figures, 255,000,000 gallons capacity, now being constructed on the Umzoniana River, sections numbers 16 and 17, which property has been acquired from Captain A. C. Wilson. There will also be constructed on this site a continuous settling tank 200 feet long by 85 feet wide and 12 feet deep (for precipitating the water when it is turbid, anterior to filtration); three filter beds, each 184 feet long by 62 feet wide; and two service reservoirs, each 200 feet long by 105 feet wide and 12 feet deep, having a combined capacity of 3,000,000 gallons. After filtration the water will be delivered to East London through a new 12-inch supply main. Originally it was proposed that the rising main from the new pumping station to the reservoir should be 15 inches in diameter. It was proposed to connect the old pumping station with the new reservoir through a 15-inch cross connection. This was proposed because the present rising mains were thought too bad to lift. However, when we commenced pumping in the spring of 1918, after the pumps had been closed down on account of the abnormal rains from the mid-winter of 1917, the rising mains were found to have deteriorated so rapidly that I judged they could not much longer be continued in service. I, therefore, proposed to lift the triple expansion steam pump and put it down at the new pumping station, and to lay down a common rising main of 20 inches diameter, and to connect the new pumping station with

the old reservoir through the three old rising mains, which will be embedded in one concrete stringer.

When the new scheme, which is now being carried out, was approved by the Administrator, the question as to whether or not we should pump direct by steam or by electricity was reserved for the decision of the Government. Tenders were invited for a steam pumping plant and an electrically-driven plant. Ultimately the Electrical Engineer (Mr. Lambe) and I recommended the Council to adopt the electrically-driven plant. This recommendation was approved by the Town Council and the Administrator, and the tender of Messrs. Blane and Co. was accepted for an electrically-driven pump to deliver 1,600 gallons per minute, to be built by Messrs. Glenfield and Kennedy. The amount of the tender was £7,320.

I think the joint report which contained this recommendation may be of interest to engineers and others who have to choose a pump for a similar service. I, therefore, attach it to this short paper. (See p. 339.) The question having again arisen as to whether or not it would be better to instal an electrically-driven centrifugal pump, rather than move the triple expansion steam pump from the existing pumping station to the new, it has been decided by the Council to call for tenders for such a plant, and subsequent to their receipt to submit the matter for the decision of the Government.

Provision has also been made in the scheme for considerably augmenting the distribution mains in town. The whole scheme was designed by the writer, and is estimated to cost £163,480.

The total length of mains in the reticulation system of the town is 27.9820 miles, and the length of the special fire mains is 12.819 miles.

The total capital value of the old waterworks is £104,026 1s. 3d.

No reliable figures are available as regards population, consumption, and revenue in the earliest years of the undertaking, but it may be interesting to institute a comparison covering the last ten years, which is disclosed by the following table:—

Year.	Population		Total.	Consumption in Gallons per Day of 24 Hours.	Revenue.		
	White.	Others.			£	s.	d.
1909	13,000	10,500	23,500	338,737	9,440	6	9
1910	,,	,,	,,	348,039	9,693	5	8
1911	,,	,,	,,	372,764	5,059	6	6
1912	14,000	11,500	25,500	413,426	11,154	17	0
1913	,,	,,	,,	443,826	13,738	1	9
1914	,,	,,	,,	462,768	14,160	12	0
1915	13,566	11,029	24,595	546,927	13,608	5	10
1916	14,000	11,041	25,041	547,212	14,239	10	7
1917	14,182	11,029	25,211	577,287	13,827	2	0
1918	14,492	11,029	25,521	561,662	12,639	6	6

The new waterworks are now in course of construction, and I hope members will have an opportunity of inspecting them. Almost the whole of the work is being carried out by direct labour.

Corrosion in Iron and Steel.

In common with other waterworks undertakings we have had the same unfortunate experience in regard to corrosion in steel, and latterly in wrought iron mains.

Parts of a 12-inch rising main and supply main that was laid in 1905 had become so perforated in 1913 that they were found unfit for further service. Some of these mains were replaced with cast iron mains, and others were successfully encased in a siftings concrete stringer octagon in shape. In all cases the steel had a minimum covering of 2½ inches of concrete.

This corrosion takes place from the outside and is undoubtedly due to salts in the soil. Where the soil was known to be brak the corrosion was most intense. We had as many as 125 distinct perforations in one length of 12-inch pipe. I had noticed that wrought iron also suffered from corrosion, but to a very much less degree; however, I found last year that mains laid in 1899 were unfit for further use. In this connection photographs, which I exhibit, of two of the mains may be of interest. So as to stop the leaks they were plugged with hardwood and dusted with neat cement. In this manner they were kept in service for some time.

Corrosion in Steel Rails.

The electrical scheme is entirely under the control of the Electrical Engineer (Mr. Lambe), but I was associated with Mr. R. L. Cousins during my first term as Town Engineer, when the scheme was constructed. The weight of the rails laid was 75 lbs. per linear yard, 15 lbs. per yard heavier than any in use in the country at the time. They were well and properly laid on a concrete stringer. However, they suffered so much from corrosion that in 1911 the lower flange of the rail had been almost entirely eaten away, and the track had become unstable. Members may be interested in inspecting photographs of these rails with which Mr. Lambe kindly supplied me, and, if they so desire, I shall be glad to show them specimens of the rails.

Settling Tanks.

Two new Settling Tanks of ½ million gallons each above the draw-off were completed in 1918, in the vicinity of the Agricultural Show Grounds. Whenever necessary, we are now able to precipitate our water anterior to filtration. We did suc-

BUFFALO WATERSHED.

Table A.—Mean Monthly Rainfall and No. of Days in Month on which Rain Fell.

MONTHS	(1) East London (West) (1880 to 1918)	(1) No. of Rain Days	(2) East London (East) (1882 to 1918)	(2) No. of Rain Days	(3) Chiselhurst (1901 to 1918)	(3) No. of Rain Days	(4) Fort Jackson (1882 to 1918)	(4) No. of Rain Days	(5) Blaney (1883 to 1918)	(5) No. of Rain Days	(6) Kei Road (1877 to 1918)	(6) No. of Rain Days	(7) King Wm's Town (Gaol) (1885 to 1918)	(7) No. of Rain Days	(8) Pirie Forest (1885 to 1918)	(8) No. of Rain Days	(9) Evelyn Valley (1887 to 1918)	(9) No. of Rain Days	REMARKS.
January ..	2·48	9·7	3·17	11·7	3·35	12·1	2·54	6·0	2·62	6·33	3·91	10·5	2·47	7·8	4·94	12·9	8·99	18·7	Mean Monthly Rainfall = 3·83
February ..	2·33	9·2	3·22	10·4	3·18	10·0	2·49	5·8	2·50	6·06	4·39	9·2	2·89	7·6	4·91	11·7	8·48	16·3	Do. 3·82
March ..	2·98	10·2	3·64	11·2	3·97	11·2	3·18	5·8	2·78	7·14	4·16	9·4	2·70	8·0	4·48	11·0	8·35	17·3	Do. 4·02
April ..	2·41	7·3	2·74	8·5	3·17	7·5	2·11	4·6	1·73	4·7	2·40	5·5	1·85	6·0	2·76	7·44	5·03	12·1	Do. 2·69
May ..	2·06	5·4	2·38	5·9	2·30	5·8	1·43	2·6	1·31	3·0	1·45	3·6	1·21	4·3	1·59	5·1	3·53	8·8	Do. 1·92
June ..	1·13	3·2	1·48	4·2	1·42	3·8	1·10	2·0	0·60	1·6	1·03	2·4	0·88	2·7	1·14	2·9	2·48	5·2	Do. 1·25
July ..	1·12	3·7	1·25	4·0	1·19	3·4	0·68	2·0	0·68	1·7	0·81	2·3	0·58	2·4	0·89	2·8	1·86	5·5	Do. 1·00
August .	1·65	4·9	2·09	6·6	1·36	5·3	1·34	3·4	0·96	3·2	1·21	3·9	1·29	4·3	1·41	4·5	3·07	8·2	Do. 1·74
September ..	2·22	7·1	3·37	8·7	3·35	8·1	2·30	4·7	1·60	4·2	2·35	6·2	1·68	5·2	2·73	7·6	5·72	13·0	Do. 3·26
October ..	2·68	9·6	3·83	11·2	4·02	10·4	3·51	6·2	2·47	5·8	3·72	8·4	2·38	7·0	4·24	0·7	9·19	16·0	Do. 4·00
November ..	2·50	9·2	3·22	10·9	2·97	9·8	2·69	6·0	2·27	6·0	2·99	8·5	2·20	7·0	4·11	10·6	6·[illegible]0	15·0	Do. 3·29
December ..	2·37	8·7	3·33	10·6	3·31	10·0	2·72	4·6	2·34	5·7	3·53	8·1	2·50	7·2	4·66	11·1	8·30	16·0	Do. 3·67
Totals ..	25·93	88·2	33·72	103·9	33·59	97·4	26·09	53·7	21·86	56·2	31·95	78·0	22·63	69·5	37·86	98·03	72·7[illegible]	152·1	

Note.—Reading of Gaugès: Stations 6 = 40 yrs. Do. 5 = 30 yrs. Stations 2, 4, 7 & 9 = 34 yrs. Do. 3 = 18 yrs. Station 1 = 39 yrs. Do. 8 = 34 yrs.

Mean annual rainfall whole area excluding Chiselhurst = 34·09
Do. Do. including Do. = 34·04

cessfully use from ½ to 3 grains of sulphate of alumina. However, we find it unnecessary to use any coagulant at all excepting when the water is turbid as a consequence of rains falling in the Amalinda Watershed. In connection with this scheme we laid a couple of thousand feet of 18-inch reinforced concrete pipes. Our experience with these pipes was not altogether satisfactory. With a head of less than 28 feet we had 20 leaks through the bodies of the pipes and 69 defective joints. This experience would appear to call for great caution before adopting reinforced concrete pipes where they have to be subjected to any considerable pressure.

Settlement in Embankments.

The earthen embankment of the Amalinda Reservoir was completed in 1884. The total height above the draw-off was 27 feet. Presuming it had been made level, I found in 1917 that it had settled in the gorge 2 feet. Had it been raised in the centre at the time of construction, as is required in good practice, then the settlement was greater.

Rainfalls and Yield of Watersheds.

The accompanying table (A) shows the mean monthly rainfalls of some nine stations in the watershed of the Buffalo River, for periods varying from 18 to 40 years, and the mean yearly rainfall of all the stations, including Chiselhurst. I think this table may prove of interest to agriculturists, hydraulic engineers and others.

Mr. T. George Caink, Borough Engineer of Kingwilliamstown, has been good enough to furnish me with the run-off of the Pirie catchment area from September, 1906, to August, 1907, and from 1911 to 1918. It will probably be known that the Buffalo River has its source in this watershed, the extent of which is 14½ square miles. The following table (B) shows a mean annual run-off of 26.95 per cent. I think this table is of great value.

BUFFALO WATERSHED.

Table B.—Run-off from Pirie Catchment Area.

Year.	Rainfall.		Run-off Million Gallons.	Percentage Run-off.	Remarks.
	Evelyn Valley.	Pirie.			
1906 to 1907	99·36	48·95	4,440	27·9	From Sept., 1906, to Aug., 1907.
1911	100·34	42·35	4,968	32·7	
1912	73·03	30 05	1 980	18 3	
1913	74·79	43 96	3,082	26·3	
1914	92·18	42·78	4,156	30·0	
1915	78·21	29·62	2,575	23·0	
1916	77·06	29·32	2,371	22·0	
1917	117·73	49·52	6,640	37·0	
1918	84·82	37 99	4,723	36 5	

Note.—Mean percentage run-off for the 9 years = 26·95.

Before framing my first report, dated September 14th, 1898, on the proposed augmentation of the water supply, I investigated all existing records of the rainfalls in the Amalinda Watershed to that date, and I came to the conclusion, as I stated in my report, that it was not safe to take the yield of the watershed as being more than 10 per cent. of the rainfall. In reporting in June, 1904, on the interim pumping scheme, Mr. Charles Anthony adopted the same figure, and probably such a figure may be found safe over a cycle of years. Nevertheless, it is a fact that from the end of the wet season in 1913 until the mid-winter of 1917 the percentage of off-flow from the Amalinda catchment area did not exceed ½ per cent. I mention this fact, as it goes to show what a complex subject this is, and what extreme care it is necessary for hydraulic engineers to exercise in calculating the yield of any particular watershed.

Refuse Destructor.

A refuse destructor was commenced in 1899, but it was never completed. Notwithstanding the Town Council being warned in writing that the destructor was an apparatus which depended upon the maintenance of heat, and that an attempt to use it in an incomplete and uncovered state would be sure to prove a failure, such an attempt was made; needless to say, unsuccessfully.

Beach Development.

The Council have paid considerable attention to beach development and bathing during the last 12 years. However, very little money has been available, and only one really permanent building has been erected. This is known as the Orient Pavilion. It is a double-storey reinforced concrete building. It was built by direct labour and completed in June, 1914. It cost a little under £5,000. It is now let at a yearly rental of £720.

The tidal baths are a great feature during the summer season, but the water is too cold for winter bathing. Surf bathing is indulged in all the year round, and in this connection the Council have put up extensive wood and iron and wood public dressing-rooms and cubicles.

Whereas practically no revenue was collected until 1907, the revenue from these concerns last year was £1,768 14s. 8d.

In recent years the Council have graded off and hardened the carriage-way from Rhodes Street to what is known as the Orient Beach, and taken over and opened up Signal Hill, which is one of the beauty spots on the beach. The Esplanade was widened between Currie Street and Rhodes Street, and the sand hill cut down to the 60th contour. This area has now been laid out as hotel and boarding-house sites, with a new high-level Esplanade on top of the present grass bank. Moreover, the Council have before them a proposal to expropriate the area between Rhodes Street, Rees Street, the Beach Hotel, and the Esplanade, and to replan it, possibly as shewn on a plan which I have prepared. The area is a mean one, and Quanza Street, Fitzpatrick Road, and Clifford Street meet the Esplanade practically at right angles. The gradients are steep and the junctions dangerous. The number of building lots on the area is 36, and the present valuation of the lots and buildings is £36,515. Should the area be replanned, there would be available about 23 lots for sale. The crescent would commence at the Beach Hotel and end in the high-level Esplanade before referred to. It is proposed that a large area should be reserved for gardens, band-stands, etc. The area between Inverleith Terrace and Moore Street has been planned, and one lot has recently been disposed of to the King George's Mansions Co., who are, I understand, about to erect an hotel of 100 bedrooms. Moreover, the eastern esplanade was extended from the Lime Kilns to the Blind River. Grass plots were laid out and footpaths constructed. Members may be interested in an inspection of the plans of the whole scheme.

In this connection I think I cannot do better than quote from my report on the estimates for 1919.

Main Arterial Roads, and the Moving of the E.B. Native Location.

The Town Council have not yet taken this matter into serious consideration, but it is hoped that both they and the ratepayers will very shortly do so. The report reads as follows:—"I take the opportunity of suggesting that the time has arrived when you may very well consider the removing of the location to the west bank; naturally it is a matter of which some years' notice would have to be given. This would enable you to town plan the area on the east bank of the river and northwards as far as Amalinda and Cambridge. The site of the present location absolutely prevents extension of the town in this direction. It is highly desirable that you should make accessible that part of the town for future extensions, and it is to be hoped that it will become imperative within the next few years. Main arterial roads would have to be laid down and the areas in between contoured, so that the lots could be laid out in such a manner as to make proper provision for drainage and orientation and gradients of streets. I should suggest that the first of these roads would begin at the park end of Park Avenue, cross the first creek in the vicinity of the Boer Camp, and follow the top of the watershed as far as the main road to the Amalinda village. Ultimately the following roads could be laid down:—

"No. 2 would cross the Amalinda and the Umzoniana on to the high ground between Lower Amalinda and the Buffalo River, afterwards it could be extended through Upper Amalinda skirting the proposed new reservoir as far as Wilsonia.

"No. 3 would lead from the vicinity of the Boer Camp to the bridge over the Buffalo River.

"No. 4 would be the extension of the Eastern Esplanade *via* Bats' Cave to the Nahoon Mouth, and thence through Stanmore to the Nahoon.

"The length of these roads is approximately as under:—

No. 1, 2.701 miles.
No. 2, 7.102 miles.
No. 3, 0.947 mile.
No. 4, 2.486 miles.

I exhibit a plan showing these proposed roads.

"I do not suggest that the time has arrived for macadamising these roads, but a commencement could be made in grading them off and making them into good country roads. Trees could also be planted. A great deal could be done if a reasonable sum were voted each year. I need not point out what delightful motor drives they would make; moreover, the one *via* Wilsonia would make accessible the second creek and Green Point.

"The area I would suggest being appropriated for the native location and the Indian and coloured people's village is that lying between the Buffalo River and the main road to Kingwilliamstown, bounded on the south-east by the present West Bank location, and on the north-west by the Municipal boundary. It is in extent about 500 acres, and it could be planned out in such a way as to allow both the Indian and coloured people and natives to develop along their own lines. I would suggest that the Council put up model buildings for these people, which I am sure would yield a very fair return on the capital expenditure, and enable them to live in thoroughly sanitary surroundings, which is so desirable, not alone on account of their health, but on account of the health of the white community whose servants they are.

"To the roads mentioned I would add one *via* the present pumping station through Fort Grey Forest to the main road to Kingwilliamstown just above the 5th mile post. This road would traverse the public estate and would be about 3½ miles long. It would open up country of great natural beauty."

Housing Scheme.

The Council are going to the ratepayers for authority to borrow £49,192 to enable them to erect 100 houses for Europeans, the particulars of which are as follows:—

	10 Detached Cottages, 4 Rooms each and K., P. and Bathroom.	4 Blocks consisting of 8 Cottages of 4 Rooms each and K., P. and Bathroom.	10 Detached Cottages, 3 Rooms each and K., P. and Bathroom.	4 Blocks consisting of 8 Cottages of 3 Rooms each and K., P. and Bathroom.	2 Blocks consisting of 8 Cottages of 2 Rooms each and K., P. and Bathroom.
Living Room	17 ft. x 13 ft.	17 ft. x 13 ft.	17 ft. x 13 ft	17 ft. x 13 ft.	17 ft. x 13 ft.
Bedroom ..	13 ft. x 10 ft.	13 ft. x 10 ft.			
Bedroom ..	12 ft. x 12 ft.	12 ft. x 12 ft.	12 ft. x 12 ft	12 ft. x 12 ft.	12 ft. x 12 ft.
Bedroom ..	12 ft. x 10 ft.	12 ft. x 10 ft.	12 ft x 10 ft.	12 ft. x 10 ft	
Kitchen ..	10 ft x 10 ft.	10 ft. x 10 ft.	13 ft. x 10 ft.	10 ft. x 10 ft.	10 ft. x 10 ft.
Pantry ..	10 ft. x 4 ft. 9 ins	10 ft. x 6 ft.	10 ft. x 6 ft.	10 ft. x 6 ft.	10 ft. x 6 ft.
Bathroom ..	10 ft. x 4 ft. 9 ins.	10 ft. x 6 ft.	7 ft. x 6 ft.	7 ft. x 6 ft.	10 ft. x 6 ft.
Passage ..	4 ft. 6 ins.	4 ft. 6 ins.	4 ft 6 ins.	4 ft. 6 ins.	4 ft 6 ins.
Front Stoep	6 ft	6 ft.	6 ft.	6 ft.	6 ft.
Storeroom ..	8 ft. x 8 ft.	8 ft. x 8 ft.	8 ft. x 8 ft.	8 ft. x 8 ft.	8 ft. x 8 ft.

Members may be interested in inspecting the plans showing the type of cottage we propose to adopt, and the block plan. It is hoped that we shall be able to cover the roofs with tiles or asbestone sheeting, and ceil the rooms with uralite or some such material, and we may adopt wood on concrete floors.

Orientation has been considered to the extent that the streets have been laid out in a northerly direction, and the houses are facing east and west. In East London the prevailing winds are east and west, and streets lying in that direction are not the most comfortable to live in. On the other hand, there is very little movement of air in houses which have their windows facing north and south. One gets a very much better movement of air in houses where the windows and doors are facing east and west.

We have attempted no Dutch gables or Queen Anne fronts. On the other hand, the roofs would all be hipped and the soffits fairly wide, and it is thought they would not be unsightly, and they will certainly be economical to maintain. We propose to put up cast-iron eaves gutters and down pipes, and in all cases to install cast-iron baths. Each house will have a fairly wide stoep. Consideration was given to the abolition of the passage, but it was felt that it would be objectionable for all rooms to open from the one to the other, and therefore some passage, which in this case ends at the living room (or means of communication), was absolutely necessary. It will be seen that in the case of the 3- and 4-roomed houses in terraces we

have, so as to get light and air into the back rooms, placed the kitchens, bathrooms, and pantries back to back at a distance of 10 feet from the main building, and that they are approached under covered ways.

So as to make the 3-roomed cottages in block as compact as possible, and to economise in walls, they have alternately two rooms in front and one behind, and one room in front and two behind.

The party wall will be carried up above the roof level.

As I say, we have attempted no architectural features. On the other hand, our rooms, if erected, will be moderately large and well ventilated. Moreover, we have provided good kitchen accommodation and ample provision for bathing, and for the storage of food.

Sewerage Scheme.

The Council obtained a Provincial Ordinance to carry out the Sewerage Scheme in 1912, at an estimated cost of £210,000. This Act was repealed under the General Act No. 18 of 1914, excepting so far as the rating powers under the Act of 1912 were concerned, which we retained.

The scheme was designed to deal with sewage at the rate of 60 gallons per head per day for twice the present population, and at a maximum flow of twice the mean. It was proposed to store the sewage between tides, and after thoroughly screening it, discharge it below low-water mark during the first three hours of the ebb tide, about 500 yards east of the Blind River. The method of disposal was approved by the consulting engineers, Messrs. John Fletcher and Cathcart, W. Methven, of Durban, and also by the Government engineers. Nevertheless, now that the scheme is being prepared in detail, I propose to suggest a modification of the outfall and method of disposal. Briefly, I propose that the new outfall should be at Nahoon Point, and that the sewage should be discharged below low-water mark, after screening, at all states of the tide.

Hospital Drainage.

In 1914, in collaboration with the architects, Messrs. Cordeaux and Farrow, I designed a water-borne system of sewage for the Frere Hospital, with a septic or liquefying tank. The effluent is discharged into the First Creek sewer. The tank is built in two compartments. The system is still under the control of my department. Immediately after the construction of the works I caused the sewage to run for 24 hours into alternative tanks. This time was ultimately increased to two or three days, and we are now running it continuously for a week, first into the one tank and then into the other. The remarkable thing about this tank is, that from the time it was started until to-day it has never been sludged.

Nahoon Bridge.

Although the low-level bridge at the Nahoon is being built by the Divisional Council, I think a short reference to it may be of interest.

The total length of the bridge and abutments is 331 feet. The length of the bridge between the abutments is 261 feet. It is constructed of 15 segmental arches, 15 feet wide at the springing; the radii of the arches are 8 feet 8 inches. The width of the bridge between the handrails is 20 feet. There is no parapet to the bridge, but stout wooden handrails, which, however, it is expected may be carried away in the event of the bridge becoming drowned. Otherwise, it is not anticipated that the bridge will suffer any damage from abnormal floods. The concrete is being reinforced with second-hand mine cable, to prevent temperature cracks. The estimated cost of the bridge is £3,000.

Appendix.

City Engineer's Office,
East London,
14th August, 1918.

The Mayor and Councillors,
East London.

Gentlemen,—

We have carefully examined the tenders submitted by Messrs. Blane and Co. for electrically driven and steam driven pumping plants, and beg to report as follows:—

In his report on the proposed pumping scheme, dated 21/4/17, the City Engineer submitted estimates showing the cost of pumping by steam and electricity. The estimated cost of pumping by steam for 330 days per year was £7,151 2s. 2d., and by electricity, £7,622 18s. 8d., showing a difference of from £400 to £500 in favour of steam. He attaches new estimates prepared in exactly the same way, showing the cost of pumping by steam and electricity for 240 days in the year and also for 330 days. These estimates are based upon the new tenders for the pumping plants and the present cost of coal and electricity. They show the cost of pumping by steam for 240 days per year as being £6,320 8s. 11d., and by electricity, £6,065 13s. 3d., *i.e.*, £11 8s. 7d. per million for steam, as against £10 19s. 5d. for electricity. They show the cost of pumping for 330 days in the year as being: for steam, £7,140 0s. 6d., and for electricity, £7,453 10s. 11d., or for steam, £9 7s. 10d. per million gallons, and electricity, £9 16s. 5d.

Messrs. Blane and Co., in their tender, stated that they estimated the cost of pumping by steam at £6 2s. 6d. per million, and by electricity at .6d. per B.T. unit, at £9 7s. per million gallons. Both these estimates include a contingency amount, but they had made an error in the quantity of current needed, and they have submitted new details, which we are attaching, and which show the running cost as being, under the steam pumping scheme, £4,150 per year, or £5 0s. 9½d. per million gallons, and under the electrical scheme £6,391 3s. per year, or £7 15s. 2¾d. per million gallons.

In the estimate prepared by the City Engineer, it has been provided to pay off the whole capital cost of either plants in 25 years, and the mains, buildings, etc., in 35 years, and to provide 2½ per cent. for depreciation. Naturally, these percentages necessitate the provision of much larger amounts per year under the steam pumping scheme than under the electrical, and this is the reason why the difference between the one and the other when working for the whole year has been considerably reduced.

We are in substantial agreement in regard to these estimates, excepting that the Electrical Engineer thinks that the provision of greasers with the electrical plant is unnecessary. These are estimated to cost £102 17s. 2d. per year. Moreover, he is of opinion that the difference in the cost of lubricants would be greater than that shown by the manufacturers, which is the basis that has been adopted in the estimates.

The City Engineer has set down £50 per year more for the maintenance of roadways under the steam pumping scheme than under the electrical.

Waterbound roads soon go out of repair unless there is traffic on them. On the other hand, it may be that the cost of repairs with heavy coal traffic would be somewhat greater than that estimated.

It will be noticed that should there be a slight increase of cost under the steam pumping scheme on any of these items, the difference between the total annual cost of the plants would be wiped out.

The City Engineer desires to emphasize that the Buffalo Waterworks scheme is based upon being able to abstract water from the Buffalo River night and day, whenever it is there in suitable quantity and quality; it is, therefore, absolutely necessary that the power should be available night and day and every night and day whenever needed. Further, it is, of course, understood that the agreement between the Electrical Department and the Waterworks Department as regards cost of the current should have all the force and effect of a legal contract. The charge is not to be increased excepting on the basis of the cost of coal, and it is to be reduced when the cost of coal goes down. The basis of this increase or decrease is to be at the rate of .03d. per 1s. per ton on the increase or decrease on the mean cost of coal.

The Electrical Engineer is satisfied that under the electrical pumping scheme the electrical plant with all its accessories proposed to be supplied by Messrs. Blane and Co. is adequate. As, therefore, there would appear to be no advantage in adopting the scheme involving the greater capital expenditure, and on general grounds, we recommend you to accept the tender of Messrs. Blane and Co. for the electrically driven pumps, subject to the guarantees, etc., contained in their letter dated 2/7/18, and subject to the consent of the Provincial Government.

We have the honour to be, Gentlemen,

Your obedient servants,

J. Mordy Lambe,
Electrical Engineer.

J. Powell,
City Engineer.

The following schedules give details of cost of annual working of the plant:—

Steam Plant.	£	s.	d.
Oils, as per list hereunder	64	0	0
Waste, 6 cwt. at 70s. per cwt.	21	0	0
Spares for Engine and Pumps, as list	70	0	0
Spares for Boiler, as per list	60	0	0
Spares for Economiser, per list	35	0	0
Fuel (assumed calorific value 12,500 BTU)	2,785	0	0
Wages of Staff per annum	1,115	0	0
Total per annum	£4,150	0	0

Gallons pumped per annum, allowing 23½ hours run per day, 823,440,000.

Notes.

In getting out above we have based on our experience of the engines we supplied to Glasgow Main Drainage, which have been running since 1910, and we have allowed for the following:—

	£	s.	d.
Engine oil, 100 gallons per annum at 3s. 6d. per gall. ...	17	10	0
Cylinder Oil, 140 gallons per annum at 3s. 9d. per gall. ...	26	5	0
Solidified Oil, 700 lbs. per annum at 56s. per cwt.	17	10	0
	£61	5	0
Say	£64	0	0

You will require to make any modification necessary to suit price of oil, etc., obtained at East London, and delivered at site. The same remarks apply to Waste. Spares for Engine and Pump are based on our experience of the plant for Glasgow Main Drainage, and are what we consider ample for one year's running.

Spares for Boiler are as recommended by Messrs. Babcock and Wilcox, Ltd.

Spares for Economiser are as recommended by Messrs. Green and Co.

ELECTRICALLY OPERATED PLANT.

	£	s.	d.
Oil, 290 gallons Engine Oil at 3s. 6d. per gallon; 2 cwt. Solidified Oil at 56s. per cwt.	56	0	0
Waste, 4 cwts. at 70s. per cwt	14	0	0
Spares Parts for Pumps, as per list	60	0	0
Spare Parts for Motor, as per list	50	0	0
Power, 223 B.O.T. units per hour for 23½ hours per day at .66d. per unit	5,260	3	0
Wages of Staff, as per specification	951	0	0
Total per annum	6,391	3	0

ELECTRIC PUMPING PLANT.

Working cost for 240 days per annum, 223 Pump Horse Power:—

	£	s.	d.	£	s.	d.
Current at 0.66 pence per Unit, *i.e.*, 1,284,480 units				3,532	6	5
Labour: Engineer in charge, £5 16s. per week	301	12	0			
1st Shiftsman, £4 11s. 7d. per week	238	2	4			
2nd Shiftsman, £3 17s. per week ...	200	4	0			
3 Natives at £1 per week	102	17	2			
1 Messenger at 13s. 6d. per week (52)	35	2	0	877	17	6
Stores: 35 cases oil at 42s. per case, £73 10 0						
224 lbs. solidified Oil at 10d. per lb. 9 6 8						
448 lbs. waste at 9d. per lb. 16 16 0						
For 357 days £99 12 8						
For 240 days				66	19	7
Plant: Capital charges on £7,320				546	0	6
Capital charges on Mains ... £8,434						
Tunnel ... 560						
Buildings ... 847 10 0						
£9,836 10 0 at £6 4 9 per £100				613	11	0
Depreciation Plant, Mains, Buildings, etc., 2½ per cent. on £17,156 10 0				428	18	3
				£6,065	13	3

Cost £10 19s. 5d. per million gallons.

Working cost for 330 days, Delivery 760,320,000 gallons, current 7,920 hours at 223 units per hour:—

	£	s.	d.	£	s.	d.
1,766,160 units at .66 pence				4,856	18	10
Labour: Engineer in charge, £5 16s. per week	301	12	0			
1st Shiftsman, £4 11s. 7d. per week ...	238	2	4			
2nd Shiftsman, £3 17s. per week ...	200	4	0			
3 Natives at £1 per week (47)	141	0	0			
1 Messenger at 13s. 6d. per week(52)	35	2	0	916	0	4
Stores: Oils, Waste, etc., at rate of £99 12s. 8d. for 357 days. For 330 days ...				92	2	0
Plant: Capital charges on £7,320				546	0	6
Capital charges on Mains, Tunnel, Buildings (see above)				613	11	0
Depreciation on Plant, Mains, Buildings, etc. (see above).. ...				428	18	3
				£7,453	10	11

Cost per million gallons, £9 16s. 5d.

STEAM PUMPING PLANT.

Working cost for 240 days per annum, 263 I.H.P., delivering 552,960,000 gallons per period.

				£	s.	d.
Labour: Engineer in charge, £5 16s. per week	301	12	0			
1st Shiftsman, £4 11s. 7d. per week ...	238	2	4			
2nd Shiftsman, £3 17s. per week... ...	200	4	0			
3 boys at 3s. 6d. per diem	126	0	0			
3 boys at 3s. per diem	108	0	0			
1 Messenger at 13s. 6d. per week (52)	35	2	0	1,009	0	4
Coal: £2,785 coal for 8,577.5 hours—£1,870 3s. 11d. for 240 days				1,870	3	11
Stores: Engine Oil, 12 cases at 42s.,	£25	4	0			
Cylinder Oil, 17 cases at 48s. 9d.	41	8	9			
Solidified Oils, 700 lbs. at 10d. per lb.	29	3	4			
Waste, 672 lbs. at 9d. per lb.	25	4	0			
For 357 days	£121	0	1			
For 240 days				81	7	0
Plant: Capital charges on £22,900 at £7 9s. 2¼d. per £100				1,708	3	11
Capital Charges on Mains, £8,434; Tunnel, 560; Buildings, 2,785; £11,779 at £6 4 9 per £100				734	14	3
Depreciation on Plant, Mains, Buildings, etc., 2½ per cent. on £34,679				866	19	6
Road Repairs				50	0	0
				£6,320	8	11

Cost £11 8s. 7d. per million gallons.

Working cost for 330 days per annum, delivery 760,320,000 gallons:—

Labour: Engineer in charge, £5 16s. per week	301	12	0				
1st Shiftsman, £4 11s. 7d. per week ...	238	2	4				
2nd Shiftsman, £3 17s. per week ...	200	4	0				
3 Boys at 3s. 6d. per diem	173	5	0				
1 Messenger at 13s. 6d. per week (52)	35	2	0				
3 Boys at 3s. per day	148	10	0		1,096	15	4
Coal: £2,785 for 8577.5 hours, £2,571 10s. 5d. For 330 days					2,571	10	5
Stores: £121 0s. 1d. x $\frac{330}{357}$ *vide* above					111	17	1
Plant: Capital charges on £22,900 at £7 9s. 2¼ per £100 ...					1,708	3	11
Mains, Buildings, etc., £11,779 at £6 4s. 9d. per £100					734	14	3
Depreciation on Plant, Mains, Buildings, etc., 2½ per cent. on £34,679					866	19	6
Road repairs					50	0	0
					£7,140	0	6

Cost per million gallons, £9 7s. 10d.

Gallons pumped per annum, allowing 23½ hours run per day, 823,440,000.

NOTES.—In getting out above we have based on a somewhat similar plant which we supplied to Ottawa and on the price we are at present paying for engines and solidified oil.

You will require to make any modification necessary to suit price of oil obtained in East London and delivered at site. The same remarks as above apply to waste. Spares for pumps are what we consider ample for one year's running.

Spares for motor are as recommended by makers of motors.

A LIST OF HOST-PLANTS OF SOME OF THE *LORANTHACEÆ* OCCURRING AROUND DURBAN, NATAL.

By Paul A. van der Bijl, M.A., D.Sc., F.L.S.,
Natal Herbarium, Durban.

Read July 11, 1919.

The order *Loranthaceæ* was dealt with by Harvey in Vol. II of the "Flora Capensis," and again by Sprague in Vol. V, Sec. II, Pt. I, of the same work. It embraces the two genera *Loranthus* and *Viscum*, both of which are shrubby plants which live semi-parasitically on other plants. In this latter work the Province of Natal is credited with eight species belonging to the genus *Loranthus* and eight belonging to the genus *Viscum;* of the former, four are recorded from the vicinity of Durban, and of the latter one.

From the point of view of parks, botanic gardens, and landscape gardens, these plants are not only unsightly, but, by sapping the hosts on which they grow, are enemies, and should be periodically cut out. The two probably most common around Durban are *Loranthus quinquenervis* and *Loranthus Dregei.* The former occurs specially on *Celtis Kraussiana* and the latter on *Melia azedarach.* In the parks around here the former plant is badly attacked by the mistletoe, and when the tree has lost its foliage one notices only too plainly the green growth of the mistletoe, often hanging from the branches in long festoons. As is well known, there is a layer of a sticky substance—viscin—around the seed of these plants, by means of which the seeds readily adhere to the beaks of birds eating the berries; and are spread to other branches or other trees by the bird wiping his beak on them. It is this interesting method of seed distribution which gave rise to the Dutch name "voël-ent" (bird-graft) for these plants. Dr. Wood mentions the "tinker bird" (*Barbetula pusilla*) as one responsible for spreading *Loranthus Kraussianus.* We find that the "chook," or "yellow weaver" (*Ploceus subaureus*) and the "toppie" (*Pycnonotus barbatus layardi*) are especially fond of the berries of *Celtis Kraussiana,* and we would also regard them amongst those spreading the mistletoe so common on these trees.

An interesting point in connection with these plants was brought to my notice by Mr. E. Platt, of Durban, and it would appear to be a matter well worth studying further. He observed that the larvæ of a Lasiocampid moth—*Ocinaropsis obscura,* Aur.—while feeding greedily on *Loranthus Dregei,* obtained from an orange tree, would not touch this same plant from *Melia azedarach* (Syringa). Prof. Marloth, in Vol. I of his "Flora

of South Africa," records a similar observation, where sheep feeding on *Loranthus namaquensis* growing on *Melianthus comosus* (Kruidje-roer-me-niet) are said to have died.

These mistletoes not only occur on a large number of South African plants, but have also adapted themselves to a number of introduced trees, including fruit trees. I have for some time been noting the trees attacked by them around Durban, and, as the list will also probably be of interest to other workers, it is appended. In the list I have marked the introduced host-plants with an asterisk (*). In the species of *Loranthus* the flowers are large, brightly coloured, and bisexual, whereas in the genus *Viscum* they are inconspicuous, greenish, and unisexual. For specific characters I must refer to the "Flora Capensis" already cited, and where any of the species have been illustrated I give the reference in recording the species.

My thanks are due to Mr. E. Platt, of Durban, and Mr. H. Rutter, Curator of the local gardens, for bringing several of the hosts to my notice.

I hope in time to extend this list so as to embrace all the Natal species of the genera *Loranthus* and *Viscum*, and will then also take the opportunity to add to those herein detailed. Specimens of these plants, with their hosts, from different parts of Natal will always be very acceptable.

Loranthus Dregei, E. and Z. (Flora Cap., Vol. V, Sect. II, Pt. I, p. 109), Illustrated *Natal Plants, Vol. IV, plate* 312.

Easily distinguished from other Natal species of this genus by the hairy corolla.

Acacia sp.
(*) Ailanthus malabarica, D.C.
(*) Aleurites triloba, Forst. (Candle-berry tree).
(*) Aralia leptophylla, Horst.
(*) Barringtonia acutangula, Gaertn.
Calpurnia lasiogyne, E.M.
Carissa grandiflora, A. D.C. ("Amatungulu").
(*) Cassia florida, Vahl.
(*) Casuarina equisetifolia, Forst.
(*) Cedrela odorata, Linn.
(*) Citrus aurantium, Linn. (the Orange).
Clausena inæqualis, Bth.
Cola Natalensis, Oliv.
Cordia caffra, Sond.
Dalbergia obovata, E.M. (Monkey's Rope).
(*) Diospyros sapota, Roscb.
(*) Erythroxylon coca, Lamk.
(*) Eugenia jambos, Linn.
(*) Ficus cannoni, N.E.B.
(*) Garcinia cochinchinensis, Choisy.
Gardenia globosa, Hochst. (September Bells).
(*) Grevillea Forsteri, Hort.
Hibiscus tiliaceus, Linn. (a native tree hibiscus common along the coast).
(*) Hymenospermum flavum, F. v. Mueller.
(*) Jacaranda mimosæfolia, D. Don.
(*) Magnolia grandiflora, Linn.

(*) Melia azedarach, Linn. (known in Natal as "Syringa").
Mimusops Caffra, E.M. (white milkwood tree).
(*) Mimusops Elengi, Linn.
(*) Morus sp. (Mulberry).
(*) Phyllanthus emblica, Lindl.
(*) Polyalthia suberosa, Bth. and H.K.
(*) Prunus persica, Stokes (Peach).
Psychotria capensis, Vatke.
(*) Pterospermum semi-sagittatum, Ham.
(*) Schinus molle, Linn. (Pepper tree).
(*) Sterculia discolor, F. v. Muell.
Toddalia Natalensis, Sond.
Trichilia emetica, Vahl. (Natal mahogany, "um-Khuhla").
Turraea floribunda, Hochst.
Xanthoxylon capense, Harv. (Knobthorn tree).
(*) Zizyphus jujuba, Lam.

Loranthus Kraussianus, Meisn. (Flora Cap., Vol. V., Sect. II, Pt. I, page 118). Illustrated *Natal Plants, Vol. I., Plate* 76.
Celastrus verrucosus, E.M.
Eugenia capensis, Harv.
Sapindus oblongifolius, Sond.
Scutia commersonii, Brogn.

Loranthus quinquenervis, Hochst. (Flora Cap., Vol. V., Sect. II, Pt. I, page 111). Illustrated *Natal Plants, Vol. III, plate* 295.
(*) Barringtonia acutangula, Gaertn.
(*) Brunfelsia macrophylla, Benth.
Celastrus verrucosus, E.M.
Celtis Kraussiana, Bernth. (Camdeboo Stinkwood).
Chætachme aristata, Planch ("um-Kavoti").
(*) Elæodendron glaucum, Pers.
(*) Ilex paraquayensis, Lamb.
(*) Polyalthia suberosa, BTH & HK.
Vangueria lasiantha, Sond.

Viscum obovatum, Harv. (Flora Cap., Vol. V., Sect. II, Pt. I., p. 122).
Scolopia Zeyheri, Harv. (Thorn Pear).

Viscum verrucosum, Harv. (Flora Cap., Vol. V., Sect. II, Pt. I, page 134).
This species does not appear to have been previously recorded from around Durban. It is one of the Viscums with scale-like leaves, and in its warted berries differs from the others of this sub-section occurring in Natal.
Acacia arabica, Willd. var. Kraussiana.
Acacia sp.

These Loranthaceæ flower almost throughout the year. Thus *Loranthus Dregei* was obtained in flower during the months of January, February, July, August, October, and December; *Loranthus Kraussianus* during January and February, and fruit also in January; *Loranthus quinquenervis* during January, February, May, June, and July. *Viscum obovatum* was obtained in fruit in April, and *Viscum verrucosum* in fruit during January. The observations recorded in this short paper are admittedly incomplete, and will later probably be considerably extended. The family is an extremely interesting one, owing to the semi-parasitic nature of its members, the method of seed distribution, and the pollination of the flowers of the genus *Loranthus* by sunbirds. Mr. M. S. Evans, C.M.G., described the pollination of *Loranthus Dregei* by sunbirds in "Nature"

(3 Jan., 1895). Prof. Schonland has dealt with the "Wood-flowers" on *Burkea Africana*, caused by *Loranthus Dregei* (Records, Albany Museum, Vol. II, p. 435), and in the same work records several host plants.

The main object with which I set out to note the different host plants was to supplement the records in the local herbarium and that given for this locality in the "Flora Capensis," but I hope in time to extend the observations so as to embrace other interesting points connected with these plants.

THE LENGTH OF TIME WHICH *PIROPLASMA BIGEMINUM* AND *ANAPLASMA CENTRALE* SURVIVE IN CITRATED BLOOD.

By E. M. Robinson, M.R.C.V.S.,
Veterinary Research Laboratory, Onderstepoort.

Read July 10, 1919.

The experiments described in this paper were undertaken with the object of determining how long *Piroplasma bigeminum* and *Anaplasma centrale* remained alive and capable of reproducing redwater and anaplasmosis, when the blood containing them was preserved with sodium citrate solution for varying periods of time. During the past five years blood from imported cattle inoculated with a mild strain of redwater and a strain of *Anaplasma centrale,* the mild form of anaplasmosis, has been used to immunize cattle against these two diseases in South Africa. The blood of these imported cattle was citrated, 90 parts of blood being added to 10 parts of 10 per cent. solution of sodium citrate in distilled water, and sent out to various cattle owners, the dose prescribed being 5 c.c., to be inoculated subcutaneously. A warning was given to the cattle owner that the blood should be used not later than five days from the date of issue from this laboratory. This time-limit was quite arbitrary, as no experiments had been done, at the time the vaccine was first issued, to determine the resistance of the parasites in citrated blood. During the early part of 1918, reports were received from various sources that the vaccine did not seem to produce redwater reactions, and as some of the stock-owners who made these reports were good observers, it was decided to make a few experiments in this connection. The number of available susceptible cattle was very limited at the time, April, 1918, but none of the cattle used had been exposed to either redwater or anaplasmosis infection previously.

Experiment 1.

Shorthorn heifer 4120 was inoculated subcutaneously on 2/4/18 with 5 c.c. citrated blood (90 blood to 10 of 10 per cent. sodium citrate solution) of heifer 3830, used for redwater and anaplasmosis vaccine production. Some of the blood was sent by rail to Pietermaritzburg and returned from there, the journey occupying 120 hours or 5 days. 5 c.c. of the returned blood was inoculated into heifer 4119 on 7/4/18, 4120 therefore acting as control.

Heifer 4120 showed *P. bigeminum* in the blood from the 9th to 17th days after inoculation, with a strong temperature reaction and *Anaplasma centrale* from 39th to 44th day after inoculation.

Heifer 4119 did not show a reaction to redwater, but did to *A. centrale* from the 36th to 44th day after inoculation. In order to see whether a reaction to redwater had occurred unnoticed, the heifer was bled into citrate solution on 29/4/18, and heifer 4117 was inoculated with 5 c.c. of the blood subcutaneously.

Heifer 4117 did not react to redwater, but did to *A. centrale* from the 36th to 44th day after inoculation. Both heifers 4119 and 4117, when subsequently inoculated subcutaneously with 5 c.c. each of blood of heifer 4120, a reactor to both redwater and anaplasmosis, reacted to redwater only.

Heifer 4119 showed a reaction to *P. bigeminum* on the 11th and 12th days after inoculation.

Heifer 4117. Reacted to *P. bigeminum* from the 7th to 12th days, accompanied by a slight breakdown in immunity to *A. centrale*.

In this experiment one is entitled to conclude that the *P. bigeminum* did not survive the sojourn of 120 hours in citrated blood, but that *A. centrale* did, and its virulence did not seem to have been in any way reduced.

This experiment having been concluded, an attempt was made to see whether the approximate survival period of *P. bigeminum* in citrated blood could be found. Blood was again taken into citrate solution (90 parts blood to 10 of 10 per cent. sodium citrate) from a heifer used for redwater and anaplasmosis vaccine production. Some of this was inoculated immediately into susceptible cattle; some was kept for 24, 72, and 90 hour periods, being sent by post to various places, so as to as closely as possible simulate the vaccine as used by a stock owner.

Experiment 2.

Heifer 4118. Inoculated subcutaneously on 22/5/18 with 5 c.c. of citrated blood of heifer 3831, which had been kept 24 hours. She reacted to *P. bigeminum* on 21st and 22nd days after inoculation, the reaction being a very weak one, and to *A. centrale* from the 41st to 56th days.

Heifer 4154. Acted as control to 4118, the blood being inoculated within an hour of taking. A reaction occurred to *P. bigeminum* on 20th to 22nd day after inoculation, and to *A. centrale* from 36th to 56th day with marked anæmia. Both heifers 4118 and 4154 were subsequently inoculated with blood of heifer 3831, which had been taken and used within an hour. Neither heifer gave any further reactions.

In this experiment *P. bigeminum* survived for 24 hours in citrated blood, the reactions being later in both the experimental animal and the control.

Experiment 3.

Blood from heifer 3830 was taken into citrate solution, and heifer 4156 was inoculated subcutaneously with 5 c.c., kept for 24 hours. Heifers 4331 and 4332 acted as controls, being inoculated with 5 c.c. each of the blood within an hour of taking.

Heifer 4156 did not react to redwater, but did to *A. centrale* from 38th to 51st day after inoculation.

Heifer 4331 reacted to *P. bigeminum* on the 22nd day after inoculation, and to *A. centrale* from the 45th to 51st day, the reactions in both cases being poor.

Heifer 4332 did not react to *P. bigeminum*, but a slight elevation of temperature occurred on the 14th day, with subsequent slight anæmia. A very mild reaction to *A. centrale* took place from the 44th to 50th days, only the fact that smears were taken at the time the reaction was due causing it to be noticed at all.

Heifer 4156. When subsequently reinoculated with blood of heifer 3830, within an hour after taking, the heifer reacted to redwater on 13th and 14th day. No further reaction to *A. centrale* occurred. The evidence in this experiment is not quite satisfactory, as although the experimental animal reacted properly, one of the controls did not. The controls were imported cattle, but had been in the country for some months, and although stabled during the period, may possibly have been exposed to infection.

Experiment 4.

In conjunction with experiment 2, and using the same control, a heifer 4155 was inoculated with 5 c.c. citrated blood of heifer 3831, which had been kept 72 hours.

Heifer 4155. No reaction occurred to *P. bigeminum*, but a slight elevation of temperature took place. The reaction to *A. centrale* was scarcely perceptible as well. When subsequently inoculated with fresh citrated blood of heifer 3831, no further reactions occurred. Two months later, to see what reactions the blood of heifer 4155 would produce when inoculated into a susceptible animal, a bull 4462 was inoculated with fresh citrated blood.

Bull 4462. A temperature reaction occurred on the 10th day after inoculation, but *P. bigeminum* was not demonstrable

in smears taken on that day. A mild reaction to *A. centrale* took place from the 27th to 35th days. When subsequently inoculated with 5 c.c. citrated blood of heifer 4390 (virulent redwater strain) this bull reacted strongly to redwater on 14th to 16th days, and was given trypan blue. These experiments would seem to show that if any reaction at all occurred in heifer 4155, it must have been an exceedingly mild one.

EXPERIMENT 5.

In conjunction with Experiment 3, and using the same controls, heifer 4158 was inoculated with 5 c.c. citrated blood of heifer 3830, which had been kept 90 hours.

Heifer 4158. Did not react to redwater, but did to *A. centrale* from the 30th to 45th days. When subsequently inoculated with 5 c.c. citrated blood of heifer 3830, inoculated within an hour of taking, a reaction to *P. bigeminum* occurred on 13th day, and no further reactions took place.

Although unsatisfactory, the evidence obtained would point towards the survival period of *P. bigeminum* in citrated blood being less than 90 hours. In one case it survived 24 hours, and in another it did not. It was therefore decided to repeat the experiments at the first favourable opportunity.

EXPERIMENT 6.

In October, 1918, four imported bulls were again available for experiments, their numbers being 4410, 4411, 4412, and 4413. Blood from a heifer, 4120, immune to redwater and anaplasmosis (see Experiment 1), was taken into water containing 3.8 per cent. of sodium citrate and 2.8 per cent. of saccharose, in the proportion of 90 of blood to 10 of the mixture. Both these solutions, to which the blood was added, were isotonic for blood. Bulls 4412 and 4413 were inoculated subcutaneously, each with 5 c.c. of this blood, bull 4410 with 5 c.c. kept 48 hours, and bull 4411 with 5 c.c. kept 96 hours.

Bull 4410. No redwater reaction occurred, but one did to *A. centrale* from 40th to 48th day. Subsequently, when inoculated with 5 c.c. blood of heifer 4390 (virulent redwater strain), a marked temperature reaction occurred on the 16th day after inoculation, but *P. bigeminum* could not be found in smears of the blood, though *A. centrale* was present in small numbers, probably due to a breakdown in immunity to anaplasmosis. Whether a reaction occurred in the first inoculation or not, it is therefore impossible to say, but temperatures could not be taken for a week from the 3rd to 10th day after inoculation, owing to the complete disorganization caused by the influenza epidemic.

Bull 4411 did not react to redwater or anaplasmosis, so was subsequently reinoculated with blood of heifer 4117 (see Experiment 1), immune to redwater and anaplasmosis. A reaction occurred to redwater from the 9th to 11th day, and subsequently, on 56th and 63rd days, a mild reaction to *A. centrale*.

Bull 4412. No reaction occurred to Redwater, but one did to *A. centrale* from 41st to 50th day.

Bull 4413. No reaction was noticed to redwater, but a reaction occurred to *A. centrale* from 41st to 49th day, when death occurred from acute anaplasmosis. Only the centrale form of anaplasma could be found in blood smears during life and in blood and spleen smears after death. No previous case of death from the centrale type of anaplasmosis has occurred in the history of experiments in anaplasmosis since their commencement some years ago. In the cases of both bulls 4412 and 4413 the temperatures could not be taken properly for the same reason as in the case of bull 4410.

The results of Experiment 6 were again disappointing and inconclusive, owing chiefly to uncontrollable circumstances; so that it was decided to do further experiments on 19 recently imported bulls, on which the owner was willing that experiments should be carried out.

Experiment 7.

The experimental work was arranged as follows:—Heifer 4120 (see Experiment 1), immune to redwater and anaplasmosis, was bled into varying proportions of isotonic sodium citrate solution (3.8 per cent.), to which ⅛ per cent. gelatine had been added to prevent hæmolysis. The addition of the gelatine was suggested by an article written by Peyton Rous in the "Journal of Experimental Medicine" for February 1st, 1916, Vol. 23, No. 2, in which gelatine was successfully used in keeping suspensions of red blood corpuscles from injury during washing. Blood was added to the citrate solution in the proportions of 90 to 10, 70 to 30, and 50 to 50. A control lot was made by adding 90 of blood to 10 of 10 per cent. citrate solution, as used in some of the other experiments, and a lot consisting of defibrinated blood with no addition of preservative. Bottles of each of these five batches were kept for periods of 48, 96, and 144 hours, respectively, being sent by post to various places and returned. In the bottles containing citrate solution, no hæmolysis occurred until the end of the second week in control ones sent out with those which went on journeys, so that hæmolysis could not be said to have affected the experimental results. The defibrinated blood, unpreserved, became infected with a coccus-like organism, so the bottles of it over 48 hours old were not used.

The bulls in the experiment were first of all inoculated with the various citrate solutions, those which reacted to *Anaplasma centrale* only being subsequently inoculated with blood of heifer 4390, which contained a virulent strain of *P. bigeminum*. Those which did not react to either *P. bigeminum* or *Anaplasma centrale* were reinoculated with blood of heifer 4120, the blood being inoculated directly after taking. These reinoculated cattle were subsequently inoculated with blood of heifer 4390 (virulent Redwater strain). The results are shown in the following table:—

EXPERIMENT 7.

Bull.	How Inoculated.	Redwater.	*A. Centrale.*	How long Blood kept.	Reinoculation with Blood of Heifer 4120.	Subsequent Inoculation with Virulent Redwater Blood, Heifer 4390.	Any Subsequent Reaction.
4426	Citrate sol. 50 to 50	None	Reaction 45th to 53rd day	48 hours	Not done	Good reaction 12th to 16th day	None
4454	do.	None	No noticeable reaction	96 hours	Reaction to *A. centrale* only	Reaction to Redwater 17th to 18th day	Reaction to *A. marginale* from 48th to 50th day
4455	do.	None	do.	144 hours	Reaction to Redwater only, rather severe	Not done	None
4456	do.	Reaction 10th day	Reaction 28th to 30th day	1 hour	Not done	No reaction	do.
4422	Citrate sol. 30 to 70 blood	None	Reaction 52nd to 60th day	48 hours	Not done	Died of acute Redwater on 10th day	do.
4423	do.	None	None	96 hours	Reaction to Redwater 14th to 16th day	Not done	do.
4424	do.	None	None	144 hours	No reactions	Slight reaction to *A. marginale* 50th to 52nd day	do.
4425	do.	Reaction 10th day	Reaction 40th to 47th day	1 hour	Not done	No reactions	do.
4418	Citrate sol. 10 to 90 blood	None	Reaction 40th to 48th day	48 hours	do.	Redwater reaction 17th to 18th day	do.
4419	do.	None	Reaction 42nd to 49th day	96 hours	do.	Redwater reaction 10th to 12th day	do.
4420	do.	None	Reaction 40th to 45th day	144 hours	do.	Redwater reaction on 20th day	do.
4421	do.	Reaction 11th to 12th day	Reaction 35th to 39th day	1 hour	do.	No reactions	do
4457	Citrate sol. 10 of 10 °/₀ to 90 blood	None	Reaction 47th to 51st day	48 hours	do.	Doubtful Redwater reaction 14th day	Reaction to *A. marginale* 43rd to 50th day
4458	do.	None	Reaction 43rd to 51st day	96 hours	do.	Redwater reaction 12th to 14th day	Reaction to *A. marginale* 43rd to 47th day
4459	do.	None	Reaction 49th to 51st day	144 hours	do.	Died acute Redwater on 14th day	None
4460	do	Reaction 8th to 11th day.	Reaction 36th to 42nd day	1 hour	do.	No reactions	do.
4461	Defibrinated blood.	None	Reaction 36th to 41st day	48 hours	do.	Redwater reaction on 13th day	do.
4463	do.	Reaction 10th to 12th day	Reaction 37th to 43rd day	1 hour	do.	No reactions	do.

The reactions in Experiment 7, judged by the control bulls 4456, 4425, 4421, 4460, and 4463, are much more regular than in the previous experiments. In no case did the *Piroplasma bigeminum* survive even 48 hours in citrated blood, or even in defibrinated blood. *Anaplasma centrale* in practically all cases survived the periods of keeping, though considerable lessening in its virulence undoubtedly occurred. Solutions of citrate in the proportion of 50 to 50 of blood and 30 to 70 of blood appear to be more harmful to the *Anaplasma centrale* than a 10 to 90 proportion. An isotonic solution of sodium citrate did not appear to have any superiority over a 10 per cent. solution. It will be seen from the table that in a few cases the blood of the heifer 4390 containing a strain of *Anaplasma marginale,* in addition to the redwater strain, in a few cases broke down the previous immunuity to *Anaplasma centrale* in the bulls.

Conclusion.

Judging from the experiments recorded in this paper, *Piroplasma bigeminum* in blood drawn from an immune animal will not survive in citrated blood for periods longer than 24 hours, but may survive for that length of time. *Anaplasma centrale* will practically always survive for at least 144 hours in citrated blood, if the proportion is not more than 10 of citrate solution to 90 of blood.

SOME POINTS CONNECTED WITH THE DISCOVERY OF THE CAPE BY BARTHOLOMEU DIAS, 1488.

By Rev. Canon E. B. Ford, M.A.

With 1 Map.

Read July 11, 1919.

To us, who have the privilege of belonging to the Union of South Africa, the voyage of Bartholomeu Dias is of the utmost interest, but in his own age this was not the case. The Portuguese were single-minded folk, and so the discovery of many leagues of coast and the stateliest Cape in all the world interested them only in so far as it carried them a step nearer to the realisation of their dreams of a sea-route to India or the opening up of the treasuries of the elusive Prester-John.

This dream, as regards the Indian part of it, materialised for them some ten years later, when Vasco da Gama reached Calicut, though Prester-John remains elusive to this day. Amid the splendours of the Eastern trade thus opened to the Portuguese, the man who had found the road was so far forgotten that Camoens, who in his Lusiad sings the praises of many less deserving men, makes but the barest of references to the voyage of Dias, and has not even preserved his name.

This being the case, it is not to be wondered at that the records of his voyage are few and imperfect, and that they have left for our solution a number of difficult questions concerning the voyage of our first discoverer, questions which were esteemed of little importance in the days of Dias, but which are of the greatest interest to us as South Africans.

These records of the voyage, scanty as they are, have been collected with painstaking diligence by A. G. Ravenstein, and put together in a short paper, read before the Royal Geographical Society in 1900. This paper is the result of such wide research and the critical conclusions are so sound that it may be considered to establish the main facts of the voyage. There are, however, still a few points on which Ravenstein did not pronounce an opinion or on which some later light has been thrown.

It is the object of this paper to deal with some of these points, namely:—

1. The connection of Dias with the island of S. Croix in Algoa Bay.

2. The position of the padrão of São Gregorio, the furthest of the memorial pillars erected by Dias in South Africa.

3. The identification of Dias' turning-point, the Rio do Infante.

4. The dates of the voyage.

5. The identification of the islet known as the Penedo das Fontes.

Before dealing with these questions in detail it is as well to notice briefly the authorities for the voyage.

The received account, the only one which preserves a connected record, is that by de Barros, contained in his "Asia." This account is full of interest, but is not particularly reliable. De Barros wrote some 60 years after the event, and the facts as he gives them are often in conflict with the evidence of earlier writers. He has been well called "the Portuguese Livy," and he has a share of both the merits and defects of the great Roman historian: his style is magnificent, his narrative intensely real; he makes his readers hear the swish of the water along the sides of the caravel and long to go sailing away on the track of adventure. But with it all, he is inclined to be inaccurate with regard to those facts which, *pace* Macaulay and others, are the basis of all real history. In this connection, the remarks on the classical historians of Portugal by Ian Colvin in his "Cape of Adventure" are very much to the point: "Their vivid and stately narratives tell the story of the rise of their country, the deeds of its heroes, and the beginning of its decline, with a lofty conception of the philosophy and the moral lessons of history which shows that they sat at the feet of Livy and Plutarch. But like Livy, they had unhistorical ends in view: they desired to set before the youth of a Portugal already past its first glory an exhortation drawn from their country's prime, and to this end they elevated men to the style of heroes and adorned their narratives with lofty sentiments and shining examples."

It is only fair to say that de Barros is neither as inaccurate nor as careless as others, nor does he exaggerate to the same extent as, for instance, Correa, but as an authority for the voyage of Dias he can only be received with extreme caution.

His weakness seems to lie in a tendency to write without the careful verification of his facts, and possibly to trust too much to the accepted story of the voyage current in his days; such stories grow up very easily even in our own times, and find their ways into the history books. It must not be forgotten that de Barros was a contemporary of Holinshed.

Fortunately, however, we have a certain amount of contemporary evidence on the subject of the voyage of Dias, and this evidence has been carefully reproduced in Ravenstein's paper. It is as follows:—

(*a*) There is the record of the grant of an annuity to Dias by João II, King of Portugal, "in consideration of services which he hoped to receive."

(*b*) A marginal note in a copy of Pierre d'Ailly, "Imago Mundi," written in the handwriting of Christopher Columbus.

(*c*) A similar, but less important, note by Christopher Columbus in the margin of the "Historia rerum ubique gestarum" of Pope Pius II.

(*d*) A mention of the date of the voyage by Duarte Pacheco

in his "Esmeraldo de situ orbis." Pacheco accompanied Dias home from the Island of Principe in 1488, and so received his information at first hand.

(The above are all chiefly of value as enabling us to determine the date of the voyage, but give us little further information.)

(*e*) There are some very important references to the voyage in the "Roteiro," a daily diary kept during the voyage of Vasco da Gama. This is the most trustworthy authority for the voyage of Da Gama, and the references in it to Dias are of the highest importance, as the "Roteiro" was written under the direct influence of Pero d'Alemquer, who was chief pilot to both expeditions.

(*f*) A series of contemporary maps, which have been brought to our notice by Ravenstein, and have been reproduced by him in a most useful and practical form. Of these, the most important for our purpose are the maps by Henricus Martelus, 1489; Cantino, 1502; de Canerio, 1502; and an anonymous map in the possession of Dr. Hamy, 1502.

Later writers generally reproduce de Barros' story, but the great survey of the coast made by Perestrello in 1575 is often of value, though he seems to have had little definite information about Dias and his voyage.

We will now pass on to the first of our questions.

(1) What was the connection between Dias and the islet of S. Croix in Algoa Bay?

It was formerly supposed, on the authority of de Barros, that Dias erected on the island one of the "padrões," the stone pillars, which, like Diogo Cão* and Vasco da Gama, he carried with him in order to mark the limits of his discoveries. On the subject of the padrões de Barros makes a very positive statement, but one which does not agree with the evidence of other writers, nor with the facts as they are to-day. His statement is to the effect that three were erected on the coast of Africa by Cão and three by Dias. He is certainly wrong in the case of Cão, as two of his pillars exist in nearly perfect condition, and there are considerable fragments of two others, thus establishing the fact beyond doubt that he erected four, and not three.

Of the pillars erected by Dias, that of Sant' Iago has been identified. Two fragments of the shaft are in Lisbon Museum, one in the South African Museum, Cape Town,† and

* The form of this name, which seems to be current in South African history books, is Cam, but the correct form is as given in the text and should be adopted.

† This fragment is pictured by Dr. L. Peringuey in a very valuable paper published in "Annals of the South African Museum, Vol. XIII." There is also a photograph of the last pillar erected by Diogo Cão, which gives an excellent idea of the appearance of the typical padrao

one in the Museum of Auckland, New Zealand; but, unfortunately, no legible trace of the inscription can be detected on any of these. This padrão stood on Point Dias, at the south-western point of Angra Pequena Bay. The second padrão, that of São Filipe, is said to have been erected at Cape Point. No trace of it has been discovered, and beyond the mention of it in de Barros, the only evidence of it that I have been able to find is in the shape of tiny drawings of padrões inserted near Cabo de Bõa Esperança in the maps of Cantino and de Canerio.

Of the third padrão, de Barros writes as follows:—"Santa Cruz, on the islet of that name, which is the last of the landmarks set up by Bartholomeu Dias." Against this statement must be set the positive evidence of the earlier and more reliable authorities, the "Roteiro" and the maps of Martelus, Cantino, and Dr. Hamy. All agree in placing the padrão on or near the mainland to the east of Algoa Bay, and give its dedication as São Gregorio, and not Santa Cruz. The question of the exact site of this padrão is dealt with in a later section of this paper; but for the present purpose it is sufficient to point out that the account given by de Barros is not trustworthy, and in this particular point is not merely unsupported, but has positive evidence against it.

Ravenstein, however, makes the very valuable suggestion that Dias erected a wooden cross an S. Croix as a sea-sign. The evidence in favour of this is very considerable.

In the first place, the island was regarded by the contemporaries of Dias as having played on important part in his discoveries, and the only reference to his voyage in Camoens is concerned with his visit to it.*

Again, it is most significant that in the "Roteiro" and in the two ancient maps, which give their position (Cantino and de Canerio), S. Croix and its smaller neighbours, Jahleel Island and Brenton Island, are called Ilheos da Cruz, *i.e.*, the islands of the Cross, and not the islands of the Holy Cross. The name "Holy Cross" would imply a connection with the Church Festival of the Invention of the Holy Cross, which is observed on May 3, either that the island was discovered on that date—an impossible explanation, as Dias had passed the Cape on his homeward journey by that time—or else that a padrão was

* The Lusiads of Camoens, V. 65-9:

"Aquelle ilheo deixamos, onde veio
Outra armada primeira, que buscava
O Tormentario cabo; e, discoberto
Naquelle ilheo fez seu limite certo."

"We left that islet also, where was driven
That other fleet, the first that sought to find
The Cape of Storms, the which when they had found
That island was their voyage's utmost bound."

J. J. Aubertin.

erected there which had previously been dedicated to the Holy Cross.

The name "Islands of the Cross," on the other hand, would be most appropriate if, on the larger island, a wooden cross had been erected similar to that which was afterwards erected by Vasco da Gama at Mossel Bay.

The island, which is of grey rock, and 195 feet high, is in many respects the most conspicuous object in the western half of Algoa Bay, standing out very clearly against the background of the low and sandy shore. To a voyager entering the bay after rounding Cape Recife, it would naturally suggest itself as the most suitable place on which to erect a sea-sign, and it had the added merit of being secure from the destructive activities of the Hottentots, who, on one occasion at least, destroyed a padrão and a cross erected by Vasco da Gama before he was out of sight of them. The evidence, then, as it stands, is in favour of the supposition that Dias landed on the island and erected there, not a padrão, but a wooden cross, which would serve to assist both him and subsequent explorers to correct their bearings.

2. The position of the padrão of São Gregorio, the furthest padrão erected by Dias.

Three of the maps give its position—Martelus, Dr. Hamy's, and Cantino—and all agree in placing it on the coast to the east of Algoa Bay, in the vicinity of the present Cape Padrone; but the maps are on such a small scale that it is impossible to take them as offering more than the general evidence that Dias erected the pillar within the thirty miles or so from the Cape to the Kowie. The only written evidence of early date is the reference in the "Roteiro"; but this is so important that it must be given in detail. For the sake of clearness, the modern geographical names are given after the ancient ones as they occur.

"On the morning of Friday, 15th December, we saw the land near the Ilheos Chaos (Bird Island, Seal Rock, and Doddington Rock). These are 5 leagues beyond the Ilheo da Crux (S. Croix). From the Golfo de São Braz (Mossel Bay) to Ilheo da Cruz is a distance of 60 leagues, and as much from the Cabo de Bõa Esperança (Cape of Good Hope) to the Golfo de São Braz. From the Ilheos Chaos to the last pillar erected by B. Dias is five leagues, and from this pillar to the Rio do Infante is fifteen leagues."

These distances, given by the writer of the "Roteiro" on the authority of Pero d'Alemquer, show that the latter well merited his reputation as a skilful pilot, and, indeed, that he possessed what we may call "sea-sense" to an almost uncanny degree. Two of the distances can be easily checked. Sixty Portuguese leagues are equal to 204 geographical miles, which is the correct distance from Cape Point to Mossel Bay, within

a mile or two, while from Mossel Bay to S. Croix is very little less—it is about 197 geographical miles. His accuracy at gauging distances is confirmed in other places in the "Roteiro"—the dimensions of False Bay are given as six leagues each way, which is correct to within a mile, while the distance from S. Helena Bay to Cape Point was guessed by him at thirty leagues, though he had never been in the bay before—a very remarkable guess, as the actual distance is just over thirty-two.

In his estimate of the distance from S. Croix to Bird Island he is less accurate, his five leagues being considerably under the real distance, which is about seven and a half. Perhaps the explanation of this miscalculation is that d'Alemquer had, when the "Roteiro" was written, done this part of the journey only once, as Vasco da Gama made his landfall at Bird Island, and did not enter the Bay.

His estimate for the distance from Bird Island to the padrão rested on his observations in three voyages, outward and homeward with Dias, and outward with da Gama. This would place the site of the pillar 17 geographical miles, or 19 standard miles, east of Bird Island, that is, on the coast to the east of Cape Padrone, at or near the mouth of the Bokana's River. On Vasco da Gama's voyage, Bird Island was sighted on Friday morning, but the padrão was not passed until Saturday. At that time the pillar was apparently still standing; but it has never been recorded since, and perhaps it soon met, at the hands of the natives, the fate of that erected by da Gama at Mossel Bay; da Gama actually saw natives on this coast.

In 1575, Perestrello tried to determine the position of the pillar, but had not apparently much data to go on. His language, as will be seen from the following, is very vague and uncertain:—"The Pontas da Padrão (Points of the Pillar) are four leagues east of the islets Chaos, in lat. 33, . . . its mark of recognition is 2 points of sand rising steeply from the sea, with a flat patch of bushes above, and close by is an islet . . . which may be as large as a caravel. This is *probably* the place where the pillar of São Gregorio stood, which Bartholomeu Dias set up when he was exploring that coast by order of the King, Dom João the Second, for *it is stated* that he left it fixed in an islet between the Chaos and the Rio Infante, in which locality there is no other, and therefore I gave it this name."

The spot described by Perestrello is not our modern Cape Padrone, which he has previously described as follows:—"Thence (*i.e.*, from the islets called Chaos) towards the north-east there is a point east by north, which ends very low in the sea, with great sandflats along the shore between black patches of bushes." This is the exact bearing of our Cape Padrone from Bird Island.

From a careful exploration of some thirty miles of that coast, I am able to vouch for the fact that there is only one

spot which meets the description of Perestrello's Points of the Pillar. This is Kwaaihoek, or False Islet, some three or four miles west of the mouth of the Bushman River. There alone did I discover pillars of sandstone rising steeply from the sea and crowned with bushes—they are the most conspicuous natural objects on that coast. As for the rock like a caravel, it lies off the western pillar, and the resemblance in size and shape to a dismasted ship is most noteworthy. There is, moreover, a boat-landing in the little bay between the two points, and, as far as my observation goes, I should say that it was the only boat-landing that is in use at the present day in all the thirty miles of coast between Cape Padrone and the Kowie.

The fact that Perestrello, possibly with less information than we have on the subject, fixed the site of the padrão at Kwaaihoek, does not prove very much, but it is in accordance with what other evidence we possess—the "Roteiro" and the ancient maps. It was at this point, according to de Barros, that Dias and his crews made their great discovery that the coast trended to the north-east, and it was doubtless this discovery that induced them to seek a landing-place and erect a permanent memorial of their achievement. In the miles of sandhills which form the coast there are just these two striking pinnacles to form a sure base for the padrão, and, amid all the tangle of reefs, just the one safe little opening where the caravels could ride at anchor while the boat carried the pillar through the gap to the safe landing-place.

3. The identification of the Rio do Infante, the point at which Dias turned back.

The last pillar was the scene of an important council. Dias was convinced that he had found the way to India, and was anxious to press on; but his sailing orders forbade him to take any important step without consulting with his officers. At the council they showed themselves less stout-hearted, or, perhaps, more prudent, than their commander. They urged that the state of their equipment and provisions did not justify them in extending their voyage. Dias was compelled to give way, but his companions met his views to the extent of agreeing to sail for three more days to the east, while he himself consented to return if no startling discovery were made in that time. During these three days no great change in the character of the country was to be observed, and Dias gave the order to turn back, just as they were off the mouth of a little river. João Infante, the second in command, landed here, and the river was named in his honour Rio do Infante. Later Portuguese writers identified this with the Great Fish River, an identification which, to my mind, has little to commend it. d'Alemquer gives the distance from the padrão to the turning point as 15 leagues, 51 geographical miles, and there

is but one river that can be fitted in with his description, the Keiskama. I am glad in this connection to be able to claim the great name of Dr. Theal in my support, for, without definitely giving his opinion, he has suggested the Keiskama as an alternative to the Great Fish.* The identification of the Rio do Infante with the Keiskama is also strongly supported by the facts of Vasco da Gama's voyage, in which the padrão was passed on Saturday morning; but the Rio do Infante not until Sunday night. From the "Roteiro" we may gather the fact that da Gama generally covered about 10 leagues in a full day's sailing, and the account gives the impression that on these two days in particular good progress was made; so that fifteen leagues for a day and a half would be quite a normal rate. In the absence of any strong evidence to the contrary, the Rio do Infante must be identified with the Keiskama.

While on the subject of the turning-point of Dias, it must be noted that Professor Schwarz, in a paper read before this Society in 1912, has attempted to make out a case for the Kowie being the Rio do Infante. To my mind, on very insufficient evidence, he has placed the last padrão at Fountain Rock, near the mouth of the Kowie, and has assumed that Dias turned back immediately after erecting it, an assumption which is entirely in conflict with the statements of de Barros and the "Roteiro," that Dias sailed for some distance further before reaching the Rio do Infante.

4. The dates of the voyage.

Most historians give the general date of Dias's voyage as 1486-87, but Ravenstein has satisfactorily shown that this date, derived from de Barros, is wrong.† The contemporary writers, Pecheco, the grant from João II., the notes by Columbus, show most clearly that he must have left Lisbon in July or August, 1487, and arrived home in December, 1488.

His journey along the coast from the Congo onwards is marked on the ancient maps by the names which he gave to prominent places as he passed them. These names, in accordance with the pious practice of the time, were taken from the Church Kalendar, thus dating the discoveries as well as naming them. The names given by Dias are well worthy of a more extended notice than I have given them in this paper, in which I do not propose to do more than deal very briefly with those of South African interest.

* "The Beginning of South African History." Dr. Theal, p. 129.

† Dr. Theal, in "William Adrian van der Stel and other Historical Sketches," rejects Ravenstein's theory, without, however, bringing forward any serious arguments against it, or dealing with it in detail. It is maintained by Professor Beazley ("Encyc. Brit.") and Mr. K. G. Tayne, "Vasco da Gama and his Successors."

From the maps we gather that, on leaving Angra Pequena Bay, he passed, in succession, the Golfo de São Estevão (Elizabeth Bay), Dec. 26, 1487; named the country to the south Terra de Silvestre, Dec. 31; losing sight of the coast at Sierra dos Reis (Piquetberg) on Jan. 6, 1488. Then followed his long stretch to the south, and then to the north-east, in the course of which he doubled the Cape without knowing it. He made his landfall at Mossel Bay, and gave to the cape at the entrance of the bay the name which it still bears, Cabo de São Braz (Cape of S. Blaise), Feb. 3. John of Empoli, a supercargo in d'Alberquerque's fleet, gives us the definite information that the cape was so named because it was discovered on S. Blaise's Day, so fixing the date, Feb. 3, 1488, as that of the discovery of our land.

Two other dates of importance may be mentioned. The last padrão was dedicated to S. Gregory, and may have been erected on his day, March 12, which fits in well with the known dates of the voyage; while the padrão of S. Philip, said to have been erected on Cape Point, may date the discovery of the Cape itself, May 1, 1488. It must, however, be noted that it is by no means certain that these were erected on the day of the saint which they commemorate. Certainly, in the case of Diogo Cão's voyage, the padrões were dedicated in Portugal before the expedition sailed.

5. The identification of Penedo das Fontes.

There is a certain rock or islet called Penedo das Fontes, which is mentioned in connection with the voyage of Dias, and which presents a difficult problem in identification.

On the one hand, Pecheco, supported by de Barros, places it in Algoa Bay, and identifies it with S. Croix. On the other hand, the map of Martelus has an Ilha de Fonte east of the padrão of S. Gregory, and so, apparently, has Cantino's chart; but the name in the latter is partly obliterated and so uncertain, Penedo das. . . .

Perestrello supports the view of the maps:—"Eight leagues before reaching the River Infante some low openings are seen on the coast, and three leagues further on are some rocky banks, near which is the rock that is called das Fontes, which is a rock with a cleft in the middle, and it looks like an islet, but is not one." It must be remembered that, according to Perestrello, the Great Fish River is the Rio do Infante. The low openings referred to are the mouths of the Bushman and Kareiga Rivers, and the rock in question has been identified by Ravenstein with Ship Rock, which is at about the right distance from the Bushman River. Professor Schwarz, however, places it at Fountain Rock, off the Kowie; but, to my mind, this theory locates the rock too far to the east.

To return to the Algca Bay theory, de Barros says that Penedo das Fontes is an islet, half a league from the coast, and that it received its name from the fact that there were two fountains there. It would appear that there is some confusion here between the two principal islands of the S. Croix group. S. Croix itself, with which he identifies it, is more than half a league from the shore; but Jahleel is about that distance, and lies directly off the mouth of the Coega River. At this spot, on the farm now known as Houghton Park, there are very remarkable springs of fresh water, which gush up from the sand right on the sea-shore. It would seem that Pecheco and de Barros had before them descriptions of the two islands, da Cruz and Penedo das Fontes (S. Croix and Jahleel), but did not know that they were distinct, and so combined the two in their accounts.

It is more difficult to explain the maps and Perestrello. Ship Rock and Fountain Rock are mere boulders, quite devoid of springs, and without any on the adjacent mainland, and the former, which fits Perestrello's description better, is a small and not very striking mass of sandstone, only a few yards out to sea.

Perhaps the true solution is that the spot was wrongly placed on some chart, and that Perestrello, thinking it necessary to identify Penedo das Fontes somewhere between the Bushman and the Kowie, selected Ship Rock as being the only isolated rock in those parts.

There are various other points of interest connected with the epoch-making voyage, which I should like to deal with, but I feel that this paper has reached its just limits, and they must be left for a future occasion. In conclusion, may I be permitted to say that, though some of my deductions may, and probably will be, combated, the preparation

of this paper, involving, as it did, some years of study, has been a great pleasure. In the wide range of historical studies, there are no figures more fascinating, no characters more stimulating to our own weak endeavours, than those of the great explorers and discoverers. Bartholomeu Dias remains a little wrapped in the mists of age; we cannot always see the man himself as clearly as we would, and there are gaps in his life which we cannot fill. But we have the solid fact to go on that he discovered more leagues of new coast than even da Gama, who, as soon as he reached Mozambique, was once more in known waters, and we remember, too, with reverence that Dias left his bones in our own seas. Early in May, 1500, Dias, then a captain in Cabral's fleet, left the coast of Brazil to sail to the Cape. Some three weeks later came the dreadful storm which was to give to the Cape its sinister name of Tormentoso.* Of the last moments of Dias we know nothing; but we can be quite sure, from what we can gather of his life of patient service of his King, and his splendid enthusiasm, that when his water-logged caravel disappeared beneath the waves, the Commander was on deck, looking eastward to the land of Good Hope.

"Cujus animam curet Deus una cum animis omnium nautarum fidelium."

NOTE.—The quotations from de Barros and the "Roteiro" are taken from the "Cape of Adventure," by Ian D. Colvin; those from Perestrello from Dr. Theal's "Records of South-Eastern Africa." I have generally, for the sake of clearness, given the place-names in the forms previously used in my article.

* De Barros' story that Dias originally gave this name to the Cape, and that it was changed by King João II. is now generally rejected. The early writers credit Dias himself with the touch of poetic genius which produced the beautiful name, Cape of Good Hope. It seems that the story has undergone a process of inversion not very rare in history, and that the real origin of the name Tormentoso is to be found in the disaster that overtook Cabral's fleet; Dias had fair weather in rounding the Cape.

THE ORDER PRIMULINES (MYRSINACEÆ, PRIMULACEÆ, AND PLUMBAGINACEÆ), AS REPRESENTED IN THE TRANSVAAL.

By Inez C. Verdoorn,
Division of Botany, Pretoria.

With 9 Maps.

Read July 11, 1919.

When examining the material in the National Herbarium, Pretoria, of the above families, I noticed that very few Transvaal localities were given for the species in the "Flora Capensis." This led me to examine all the available material in the South African herbaria, with a view to extending our knowledge of their geographical distribution. Mrs. R. Pott, the Curator of the Transvaal Museum Herbarium, very kindly allowed me to borrow the material in the Herbarium under her care; Dr. Schönland, of the Albany Museum, Grahamstown, sent me on loan two species represented in his Herbarium which I had not seen; and Mrs. F. Bolus, B.A., and the Director of the S.A. Museum gave me references from their respective herbaria of species recorded from the Transvaal.

The examination of all the material has established the fact that in the Transvaal we have 11 species, representing the order *Primulines,* made up as follows: *Myrsinaceæ* (3 species), *Primulaceæ* (6 species), and *Plumbaginaceæ* (2 species). Burtt-Davy quotes 10 species from the Transvaal; the species he does not mention is *Lysimachia africana* Engl. In the "Flora Capensis" only five species are recorded from the Transvaal; no Transvaal localities are given for *Plumbago capensis, Lysimachia africana, Anagallis nana, Samolus valerandi,* nor *Myrsine melanophlœos;* neither is the genus *Samolus* recorded from the Transvaal.

It is difficult to understand why Wright did not record *L. africana* Engler, in the "Flora Capensis." This species is mentioned in the *Pflanzenreich* (a work to which Wright refers under *L. parviflora*), by Pax and Kunth, as being collected in

the Transvaal. Wright quotes Mudd as the collector of *L. parviflora* Baker, while Pax and Kunth quote the same collector under *L. africana* Engl. Without seeing Mudd's specimen it is impossible to say whether Mudd collected both species, or whether Wright regarded Mudd's specimen as *L. parviflora* Bkr., and Pax and Kunth regarded it as *L. africana*, or whether Wright made a mistake and intended to refer to *L. africana*, and not to *L. parviflora*. In any case, there appears to be very little difference between the two species.

Myrsine africana is the most widely distributed species in the Transvaal, but is also common throughout South Africa, and according to the "Flora Capensis" also occurs in Tropical Africa and extends from Arabia to Central China. *Mæsa rufescens* is confined to the mountainous region of the Eastern Transvaal, but extends southwards into Natal. *Plumbago capensis* is essentially an Eastern Province species, and it is probable that its presence in the Transvaal may be due to its introduction into cultivation. *Anagallis arvensis*, a common European species, has long been naturalised in South Africa, and is now established in the Transvaal. *Dodecatheon meadia* Linn., recorded by Burtt-Davy as an alien, I have not seen, and as it is not a firmly established plant like *Anagallis arvensis*, I have not included it in the list below.

ORDER PRIMULINES.

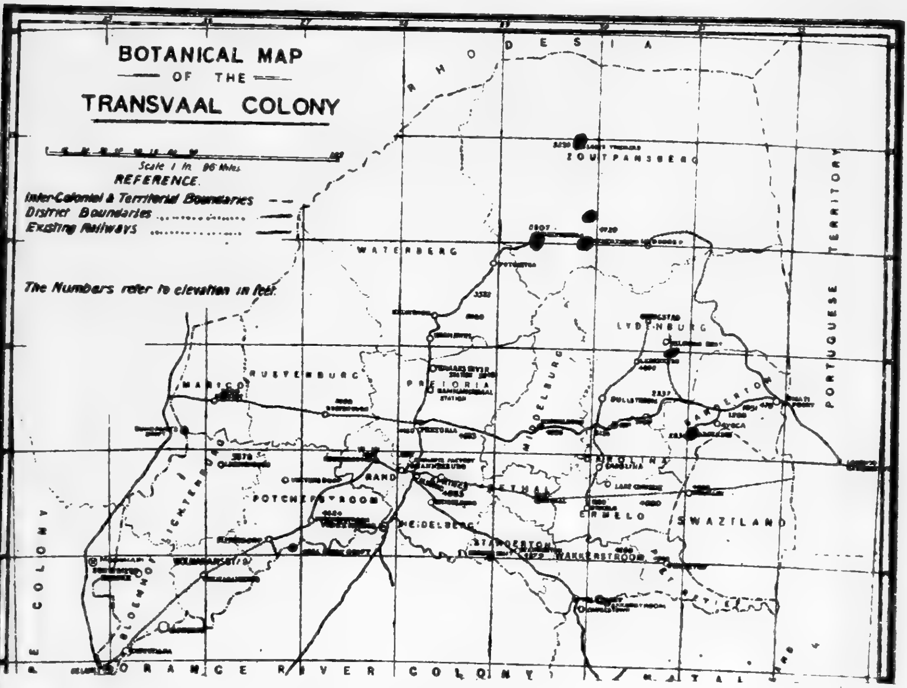
Ovary 2-∞-ovuled; style simple.	
Fruit indehiscent.	1. *Myrsinaceæ*.
Fruit capsular.	2. *Primulaceæ*.
Ovary 1-ovuled; style or style branches 5.	3. *Plumbaginaceæ*.

Myrsinaceæ.

Ovary inferior or half-inferior; seeds many.	*Mæsa*.
Ovary superior; seeds solitary.	*Myrsine*.

Mæsa, Forsk.

M. rufescens. A.DC. Zoutpansberg Dist.: Haenertsburg, Nov., *R. Pott in Herb. Transvaal Mus.* 13369; Louis Trichardt, Feb. *Dr. Breyer in Herb. Transvaal Mus.* 19505; Houtbosch, Rehmann 6012. Lydenburg Dist.: Sabie, Nov., *F. A. Rogers in Herb.. Transvaal Mus.* 14863 Barberton Dist.: Roses Creek, Barberton, Feb.. *Thorncroft in Herb. Transvaal Mus.* 2966; Rimer's Creek, Barberton, Aug.-Sept., *Galpin* 482; Barberton, Dec., *Legge in Colonial Herb.* 1743; nr. running water, Barberton, 3,000-4,000 ft., Sept.-Nov., 1889, *Galpin* 514.

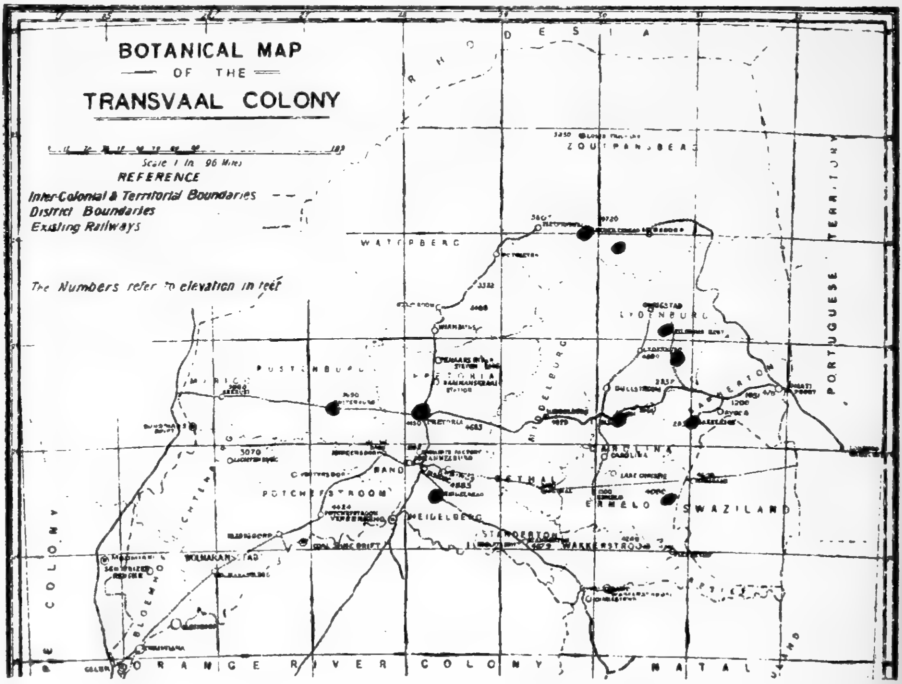


Mæsa rufescens, A. DC.

Myrsine, Linn.

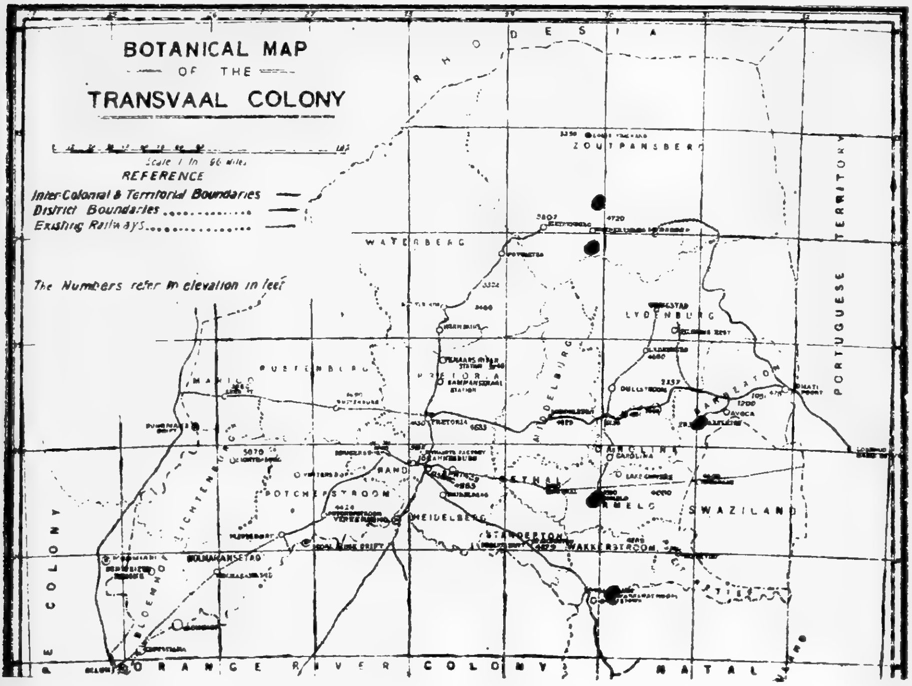
Leaves serrulate beyond the middle. *africana.*
Leaves quite entire. *melanophlœos.*

M. africana, Linn. Zoutpansberg Dist.: Shiluvane, *Junod* 1269; Haenertsburg, Nov., *R. Pott in Herb. Transvaal Mus.* 13365; Helpmakaar, Jan., *Burtt-Davy* 1222; Lydenburg Dist.: Pilgrim's Rest, Jan., *Burtt-Davy* 1581; Sabie Hoek Forest, Jan.: *Burtt-Davy* 1527. Barberton Dist.: Rimer's Creek, Barberton, Sept., *Thorncroft* 1024 in *Herb. Transvaal Mus.* 19255. Carolina Dist.: Waterval Boven, June, *Rogers in Herb. Transvaal Mus.* 12244; Ermelo Dist.: Mavieriestad, Nov., *R. Pott in Herb. Transvaal Mus.* 14960. Heidelberg Dist.: Heidelberg, Oct., *Elbrecht in Herb. Transvaal Mus.* 19210; Schoongezicht, Nov., *Burtt-Davy* 15442; Schoongezicht, Dec., *Burtt-Davy* 17107. Pretoria Dist.: Aapie's River, Pretoria, Sept., *Leendertz in Herb. Transvaal Mus.* 7209; *Bachmann* 4049. Rustenburg Dist.: Rustenburg, Oct., *R. Leendertz in Herb. Transvaal Mus.,* 9662; Blauw Bank, Limpopo Sources, *Nelson,* 265 *in Herb. Transvaal Mus.* 11613.



Myrsine africana, Linn.

M. melanophlœos R. Br. Zoutpansberg Dist.: Woodbush, Sept. and Oct., *Legat in Herb. Transvaal Mus.* 9706; Houtboschberg, Feb., *Nelson in Herb. Transvaal Mus.* 11570. Barberton Dist.: Barberton, Dec., *Thorncroft in Herb. Transvaal Mus.*, 1009; Barberton, Aug., *Galpin* 516. Ermelo Dist.: Nooit Gedacht, Ermelo, Dec., *R. Pott in Herb. Transvaal Mus.* 14963. Wakkerstroom Dist.: Wakkerstroom, Sept., *Burtt-Davy* 1491.



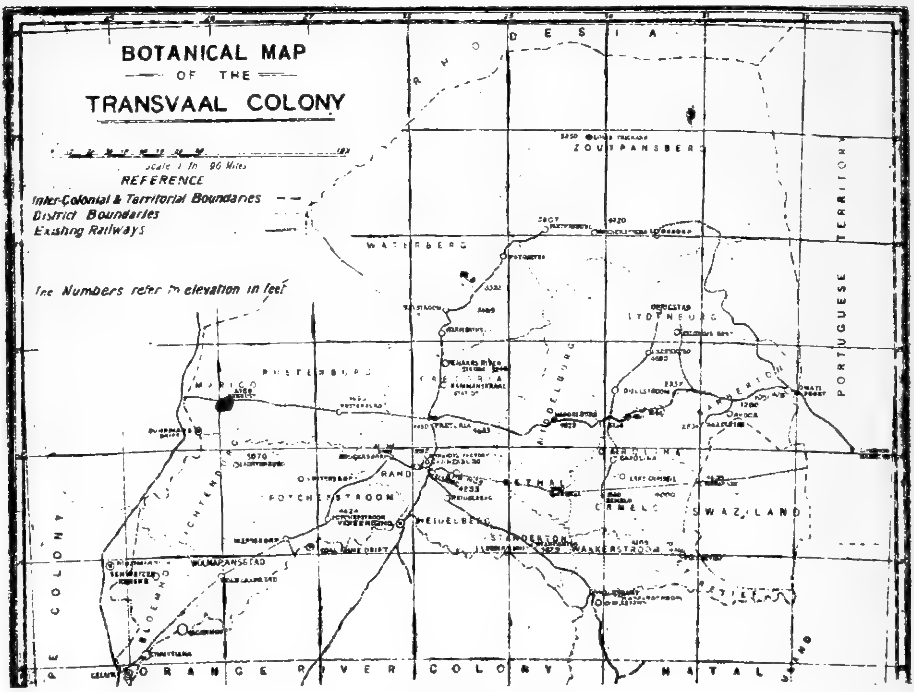
Myrsine melanophlœos, R. Br.

Primulaceæ.

Ovary half-inferior; staminodes present; capsule 5-valved.	*Samolus.*
Ovary superior; filaments hairy, staminodes absent; capsule circumcessile.	*Anagallis.*
Ovary superior; filaments glabrous, without staminodes, capsule 5-10-valved.	*Lysimachia.*

Samolus Linn.

S. Valerandi Linn. Zoutpansberg Dist.: Spelonken, Sept., *Jenkins in Herb. Transvaal Mus.* 13903; Marico Dist.: Zeerust, Jan., *R. Leendertz in Herb.. Transvaal Mus.*, 13229; Melansene, Sept., *Rogers in Herb. Transvaal Mus.* 2612.



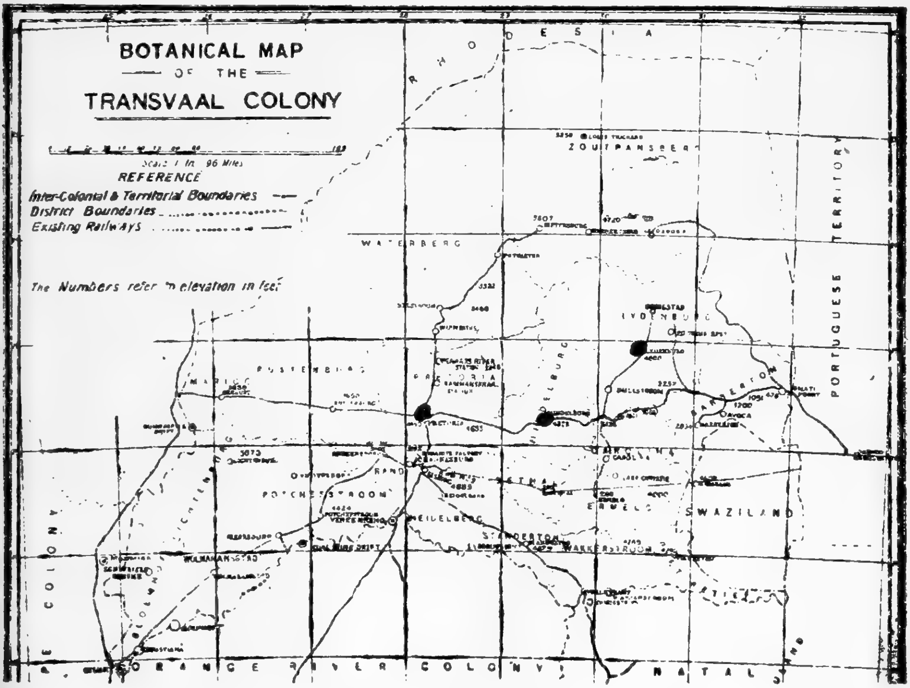
Samolus valerandi, Linn.

Anagallis Linn.

Pedicels shorter than the leaves. *nana.*
Pedicels longer than the leaves.
 Pedicels less than twice as long as leaves, recurved in fruit. *arvensis.*
 Pedicels several times as long as leaves, not recurved in fruit. *Huttoni.*

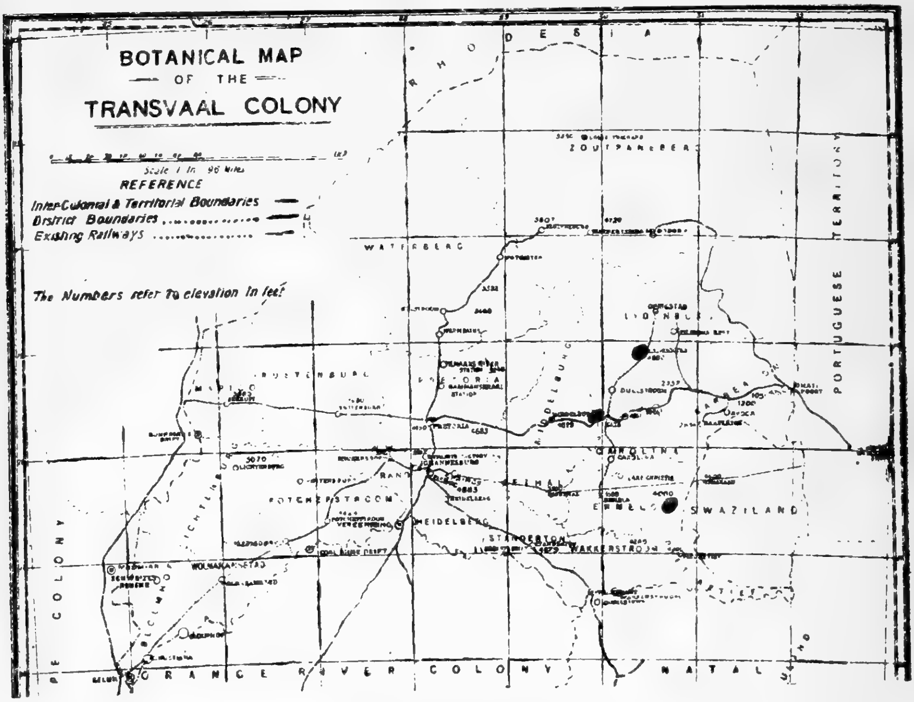
A. nana Schinz. Transvaal, nr. Rietfontein, Oct., *Schlechter* 3569.

A. arvensis Linn. Middelburg Dist.: Middelburg, Dec., *Gilfillan in Galpin Herb.* 7221. Pretoria Dist.: Aapie's River, Pretoria, Sept., *Leendertz in Herb. Transvaal Mus.* 10566. Lydenburg Dist.: nr. Lydenburg, *Wilms* 1244.



Anagallis arvensis, Linn.

A. huttoni, Harv. Ermelo Dist.: Mavieriestad, nr. Waterfall, Nov., *Pott in Herb. Transvaal Mus.* 14959; *Pott* 4937. Lydenburg Dist.: nr. Oneill's Farm, *Wilms* 1243. Middelburg Dist.: Belfast, Dec., *Leendertz in Herb. Transvaal Mus.* 10365.



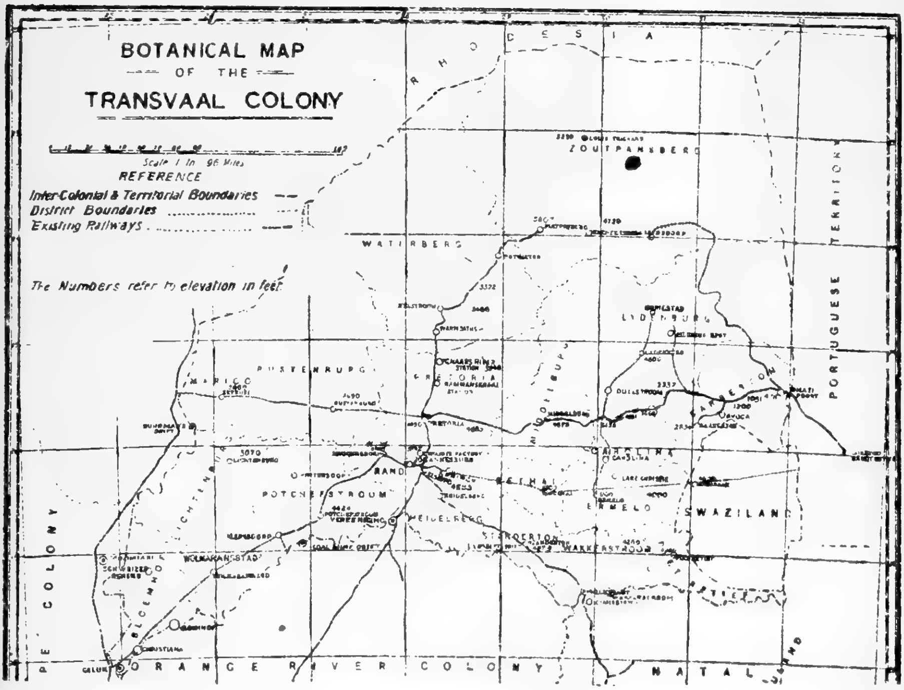
Anagallis huttoni, Harv.

Lysimachia.

Bracts lanceolate; capsule 5 mm. in diameter. *parviflora.*
Bracts linear; capsule 3-4 mm. in diameter. *africana.*

L. parviflora Bkr., Transvaal, Mac Mac, *Mudd.*

L. africana Engl. Zoutpansberg Dist.: Valdezia 1800. Feb., *Schlechter* 4533.



Lysimachia africana, Engl.

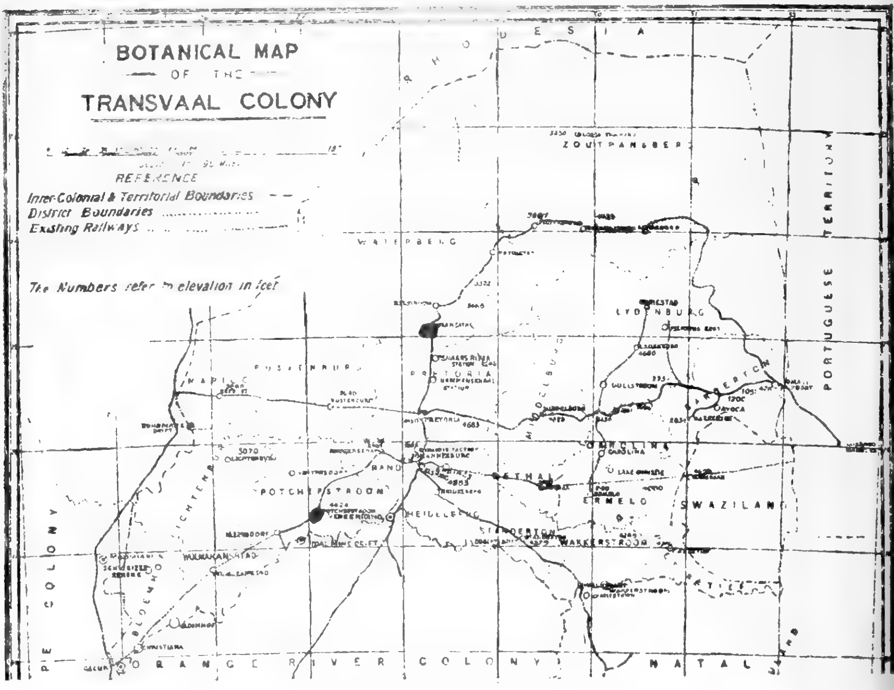
PLUMBAGINACEÆ.

Plumbago.

Axis of spike puberulous; calyx bearing stalked glands on upper half only; corolla-tube three times as long as calyx—*capensis.*

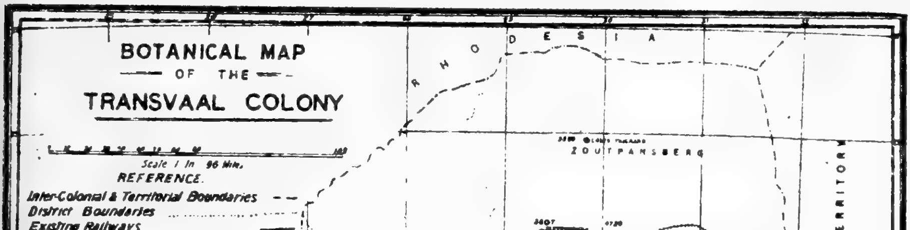
Axis of spike glandular; calyx bearing stalked glands throughout its length; corolla-tube twice as long as calyx—*zeylanica.*

P. capensis Thunb. Zoutpansberg Dist.: Free State, Zoutpansberg, July, *Dr. Breyer, in Herb. Transvaal Mus.* 18641. Potchefstroom Dist.: Potchefstroom, Jan., *Acheson in Herb. Transvaal Mus.* 5940. Waterberg Dist.: Warmbaths, Jan., *H. Bolus* 15939.



Plumbago capensis, Thunb.

P. zeylanica L. Zoutpansberg Dist.: Tzaneen, Aug., *Pole Evans in Colonial Herb.* 3985; nr. Nuanetsi, North Zoutpansberg, July, *Breyer in Herb. Transvaal Mus.* 16040. Barberton Dist.: Berea, Barberton, 2,918 ft., *Thorncroft in Herb., Wood* 3774; Kaap-Valley, Barberton, 2,000 ft., *Galpin*, 1298, 1349; Barberton, Jan., *Thorncroft in Herb. Transvaal Mus.* 4977; Queen's River Valley, Barberton, Feb., *Galpin* 1298; April, 1349; Krokodilpoort, April, *Breyer in Herb. Transvaal Mus.* 13853; Crocodile Riv., April, *Jenkins in Herb. Transvaal Mus.* 12707. Waterberg Dist.: Warmbaths, Sept., *Leenderts in Herb. Transvaal Mus.* 5605; Geelhoutkop, nr. Kloof, Jan., *Breyer in Herb. Transvaal Mus.* 16040; Wylie's Poort, Feb., *Breyer in Herb. Transvaal Mus.* 19504.



Plumbago zeylanica, L.

SOUTH AFRICAN CERCARIÆ.

By F. G. Cawston, M.D. Cantab.

Read July 9, 1919.

A study of the various cercariæ that have been described in South Africa shows that they are mostly distome or amphistome larvæ. There are several distinct species of furcocercous cercariæ, a large variety of leptocercous ones, a trichocercous cercaria, and possibly a few microcercous forms. Eye-spots occur in some of the leptocercous and furcocercous varieties. Without exception the larval hosts are fresh-water molluscs. Amphistomes have been observed encysting.

The occurrence of two cercariæ species in the same host individual is not uncommon. On several occasions I have found two distinct furcocercous forms in the same mollusc; on other occasions, the same individual mollusc was infested with both leptocercous and furcocercous cercariæ.

The classification of the distomes is a somewhat difficult problem until more of the life-histories have been worked out. So far, we are sure of the life-cycle of *Distoma luteum* and *Schistosomum hæmatobium* alone.

In "A Biological Survey of the Described Cercariæ in the United States," which appeared in "The American Naturalist," Vol. LIII, Jan., 1919, E. C. Faust described 81 different species of cercariæ, the life-history of only one of which had been ascertained.

It is important that the distinctive points of the various cercariæ be carefully recorded, and, where possible, compared with the structure of adult flukes. In the "Illinois Biological Monographs," Vol. I, April, 1915, W. W. Cort observed: "A combination of adult characters will often give a clue to the family, or even in a few cases to the genus, to which the cercaria belongs. Allowance must be made, however, for the fact that adult characters may be somewhat modified in the development of the cercaria."

Heavy Infestation.

There is a distinct increase in fluke-infested molluscs at certain seasons of the year. It would seem that heavily-infested molluscs die sooner than molluscs which do not harbour cercariæ, and infested specimens are more difficult to keep alive under artificial conditions.

The molluscs most heavily infested with cercariæ are *Planorbis pfeifferi*, *Limnæa natalensis*, *Physopsis africana*, and *Isidora schakoi*. The heavy infection of

Planorbis and *Limnæa* is caused by Distomes.
Isidora is caused by Amphistomes.
Physopsis is caused by Schistosomes.

Eye-spots.

There are several eye-spotted cercariæ found in South Africa, and it is of interest that an eye-spotted form found in Egypt was considered to be an avian parasite. In the Durban brickfields I have encountered three distinct species of eye-spotted cercariæ; two of these were furcocercariæ. At Potchefstroom I found *Isidora schakoi* heavily infested with amphistomes, possessing a pair of leaf-like eye-spots surrounded with branching pigment, *C. frondosa*. Mr. Grobbelaar has sent me specimens of the same cercaria from Stellenbosch. These also were found to encyst, and it is probable that it is the same eye-spotted cercaria that Dr. J. D. F. Gilchrist described as encysting in large numbers in the course of an article entitled "The Life History of *Distoma luteum* n.sp., with Notes on Some Cercariæ and Rediæ found in South Africa," "Parasitology," Vol. X, No. 3, April 29, 1918.

In South Africa five members of the binoculate group of species are recorded. Two of them are Schistosomes, two are leptocercous distomes, and one is an amphistome.

Redia-Formation.

The redia stage is not uncommon among our leptocercous cercariæ, though sporocysts without the formation of rediæ occur in several species. A redia is an adult organism which possesses a gut and pharynx. A sporocyst is an adult which has lost its digestive tube. E. C. Faust has pointed out that some sporocysts are not easily differentiated from rediæ, and may have been described as such. He says, in the "Journal of Parasitology," Vol. IV, March, 1918, "*C. echinocauda* is described as the offspring of a redia, whereas the evidence of studies on other cercariæ of the furcocercous group preponderates in favour of the development of these cercariæ within sporocysts."

Recently I have observed undoubted redia-formation in *Physopsis africana*. These rediæ were freely moving, and possessed a distinct gut distended with particles. Inside these rediæ were furcocercous cercariæ with small eye-spots, *C. oculata*.

At Potchefstroom I have isolated another species of furcocercous cercaria, *C. gladii*, without eye-spots. This cercaria also develops in freely movable organisms having the appearance of rediæ.

But I have never seen the appearance of redia formation in any *Physopsis africana* harbouring *Schistosomum hæmatobium*. The Japanese reported redia-formation in molluscs infected with the miracidia of *Schistosomum japonicum*, and rediæ, producing *Schistosomum mansoni*, are reported from Brazil. Leiper described only sporocysts and daughter-sporocysts as producing *Schistosomum hæmatobium* and *Schistosomum mansoni* in Egypt.

Rediæ are quite easily seen with the naked eye, when the liver-substance of an infested mollusc is macerated in water on a glass slide.

If it can be demonstrated that the African species of *Schistosoma* are sporocyst-produced, and never occur in rediæ, we shall have another means of differentiating the human parasites from several cercariæ which resemble them very closely.

These results may be tabulated thus:—

EYE-SPOTTED CERCARIÆ.

Amphistomes.	*Schistosomes.*	*Distomes.*
C. frondosa (Durban).	C. parvoculata (Durban). C. oculata. (Durban).	C. fulvoculata. (Durban).

OTHER CERCARIÆ.

Schistosomes.	*Distomes.*
S. hæmatobium (Durban, Maritzburg, Rustenburg, Magaliesburg, and Nijlstroom).	C. arcuata (Klerksdorp).
C. secobii (Maritzburg).	C. comma (Muizenberg).
C. gladii (Potchefstroom).	C. obscura (Maritzburg).
	C. catenata (Durban, Magaliesburg, Klerksdorp, and Rustenburg).

THE RARE EARTH METALS.—Many a striking instance of the "practical" utility of research in pure science has been furnished during the last two or three decades, but none more apt than the gas mantle industry, which gives employment to thousands of men, and finds profitable investment for millions of money. A Finnish professor, Gadolin, while investigating in 1794 a mineral which had been found in a Swedish quarry near the village of Ytterby, discovered a new metal, afterwards called Yttrium, the first of a series of nearly twenty, the oxides of which came to be generally known as the rare earths. For a century these seemed to have but little practical value, and few cyclopædias recorded the achievement, or even the name of Gadolin, while the village of Ytterby remained unmentioned in the gazetteers. Then it happened to occur to von Welsbach to dip a piece of cotton into a solution of one of

the rare earths and to set it alight. He had observed the intense light emitted on heating one of those oxides, and this laid the foundation of the incandescence mantle industry. At present that industry constitutes the biggest commercial development that has yet resulted from the rare earth metals, but there are quite a number of other possibilities, and Dr. J. F. Spencer, of Bedford College, University of London, has recently done excellent service in drawing special attention* to the rare earths, and in particular to the history of their discovery, their occurrence in Nature, their chemical and physical properties, and their uses. In his historical introduction Dr. Spencer sets forth lucidly the successive stages of investigation into the nature and properties of this interesting group of metals—all apparently so aimless from the viewpoint of the utilitarian, and it is significant that from Gadolin's day to our own not one decade passed without definite progress. It is impossible in the space available here to attempt even an outline of the many interesting facts collated by Dr. Spencer. The separation of the rare earths by means of fractionation is explained in sufficient detail for a work of this character, and a considerable section is devoted to the properties of the metals belonging to the group and their salts, the place of the rare earths in the periodic system of classifying the elements forming the subject of discussion in a separate chapter. In dealing with the uses of the rare earths the author rightly gives the gas mantle industry first rank, but many other uses are recorded. Thorium and its compounds, for example, are used for the headlights of motor-cars and also for searchlights, in the production of flash-light powders, for the filaments of Nernst and electric lamps, and in radiology. In many organic reactions thoria acts catalytically, aiding, *inter alia*, in the production of ethers from alcohols. Cerium earths again are used for the manufacture of pyrophoric alloys, which in turn enter into the production of automatic gas lighters, petrol lighters, and for indicating the atmospheric paths of bullets or shells. Various other uses have been found for the rare earths, but no more than bare mention can be given them here: they include the dyeing of textile fabrics, the colouring of glass and porcelain, utilisation in colour photography and other photographic processes, and medicinally as a preventive of nausea and as a non-irritant antiseptic dressing. An exhaustive bibliography, comprising no less than 1,029 titles, is appended.

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* J. F. Spencer: "The Metals of the Rare Earths," 8vo., pp. x, 279 diags. London: Longmans, Green and Co., 1919. 12s. 6d net.

A BRIEF ANALYSIS OF THE WORK OF CARL THUNBERG ON THE PROTEACEÆ.

By E. P. Phillips, M.A., D.Sc., F.L.S.,
Division of Botany, Pretoria.

Read July 11, 1919.

The author, when at Kew in 1910, and working in conjunction with Dr. O. Stapf and Mr. J. Hutchinson on a monograph of the South African *Proteaceæ* for the "Flora Capensis," was fortunate in having the opportunity of examining the specimens in Thunberg's herbarium. At the request of the Director of Kew, the authorities at the University of Upsala very kindly sent all Thunberg's material to Kew on loan. At the time several notes were made on the collection, which were intended to appear before the publication of the "Flora Capensis," but for several reasons there has been a long delay in putting these notes together.

Carl Peter Thunberg* was born at Jönköping, in Sweden, November 11th, 1743, and in 1761 entered the University of Upsala. With the aid of a small scholarship he pursued his studies in botany in Holland, and soon after accepted a post of assistant ship's surgeon, and sailed for the Cape, where he landed in April, 1772. Thunberg spent three years in South Africa, and travelled from Cape Town, along the Drakenstein, past Piquetberg, the Winterhoek, the Bokkeveld, to the Oliphant's River. Westward he journeyed by the Zwartberg, past Swellendam, the Outeniquas, over the Karroo to the Gamtoos, the Sundays and Visch River. Thunberg left the Cape for Java in March, 1775 and returned to Sweden in March, 1779 to take up the post of Demonstrator in Botany in the Royal Academy at Upsala. After the loss of the famous Linnean herbarium to Sweden, when it was bought by the English botanist, Sir James Smith, Thunberg offered his own rich collection to the University. After teaching for many years he died in 1828.

During his sojourn at the Cape, Thunberg collected 79 species of *Proteaceæ*. He published descriptions of these, but only recognized the genus *Protea* except in the case of *Brabieum* of Linnæus, which he upheld. His collection is spread over the following genera: *Brabieum* (1 species), Aulax (3 species). *Leucadendron* (21 species), *Protea* (12 species), *Leucospermum* (14 species), *Mimetes* (3 species), *Diastella* (4 species), *Serruria* (11 species), *Spatalla* (3 species), *Spatallopsis* (2 species), *Sorocephalus* (2 species). Thunberg was the discoverer of

* Presidential Address by Professor MacOwan, Trans. S. Afr. Philos. Soc., IV., Pt. 1.

the beautiful *Serruria florida* Kn., which he described and figured as *Protea florida*. This rare species was lost sight of until rediscovered by the late Prof. MacOwan in the same locality as Thunberg gathered it. Unlike other botanical collectors such as Burchell, Drège, Ecklon, and Zeyher, Thunberg recorded few localities, and neither from his publications nor from his herbarium is it possible to discover exactly where he gathered many of his *Proteaceæ*. Out of the 79 species which he collected we find only 16 with the localities given.

The examination of Thunberg's herbarium was of the utmost value in rectifying many errors of synonymy in Meisner's* monograph, which otherwise would still have remained doubtful, as evidently Meisner had not access to the collection. The examination of his specimens in connection with his publications was the only way of determining the species to which he refers in his works, and though Thunberg's descriptions are too meagre to be used as a means of identifying a species, they were very accurate of the specimens he described. Thunberg's first publication † on the *Proteaceæ* appeared in 1781, and was a considerable advance on the literature of the day dealing with this group. He gives a large amount of useful information about the habits of the species he collected, and described 60 species under the genus *Protea,* and illustrated the text with 5 plates, and for the first time figured species of *Spatalla* and *Sorocephalus*. In 1794 he published the "Prodromus Plantarum Capensium," and mentioned 61 species. It was not until 19 years afterwards that he published his first edition of the "Flora Capensis," followed in 1818 by the second edition of the same work. The whole of the work was ultimately edited from the author's manuscript in 1823 by Dr. A. Schultes, at Stuttgart. Thunberg's delay in publishing the results of his collection was unfortunate, as by the time his "Flora Capensis" appeared it was out of date as far as the information about the *Proteaceæ* was concerned, as in 1809 Knight‡ described 190 species, and a year later Robert Brown§ published a paper which contained descriptions of 181 species. Thunberg only mentions 80 species in the "Flora Capensis." In all his writings Thunberg described 84 species of *Proteaceæ,* two of which, however, were not South African, viz., *Protea hirta* Thunb., Fl. Cap. i. 454, is a species of *Isopogon* (*I. anethifolius* Kn.), collected in New Holland, and *Protea coarctata* Thunb., Fl. Cap., ed. Schultes, 122, is *Petrophila pulchella* R. Br., an Australian plant. Points such as these it was only possible to clear up by reference to his herbarium. Again, in cases where Thunberg lumped several species under one name

* D.C. Prodr. XIV.

† Botanico de Protea.

‡ "The cultivation of the plants belonging to the Natural Order Protea."

§ Trans. Linn. Soc. (1810), X.

they could only be satisfactorily unravelled by examining his specimens. For instance, *Protea conifera* Thunb. is represented by several mounted sheets, among which are included such distinct species as *Leucadendron uliginosum* R. Br., *L. strictum* R. Br., and *L. adscendens* R. Br. This is also a case, among others, where Meisner includes one of Thunberg's names in his list of insufficiently known species or species of which the genus is doubtful. Similar examples may be found in the cases of *Protea comosa* Thunb. (*Leucadendron æmulum* R. Br., *L. platyspermum* R. Br.), *P. pallens* Thunb. (*Leucadendron adscendens*, R. Br., *L. decurrens* R. Br.), *P. strobilina* Thunb. (*Leucadendron spathulatum* R. Br., *L. ovale* R. Br.), *P. speciosa* Thunb. (*Protea speciosa* L., *P. lepidocarpodendron* L.), *P. conocarpa* Thunb. (*Leucospermum conocarpum* R. Br., *L. attenuatum* R. Br., *L. ellipticum* R. Br., *L. grandiflorum* R. Br.). Several other such cases could be cited, but these will suffice to show how hopeless it would have been to straighten out the synonymy without reference to Thunberg's own specimens. Then, again, Thunberg several times described the same species under different names, *e.g.*, *Leucospermum hypophyllum* R. Br., was written up on some of his sheets as *Protea hyophylla*, on other as *Protea heterophylla; Leucadendron fusciflora* R. Br. was named *Protea torta* and *Protea tenuifolia; Leucadendron levisanum* Berg. was written up in his herbarium as *Protea levisana*, other specimens as *Protea hirsuta*. There are other cases where the same confusion occurs. It is not at all surprising that Meisner was unable definitely to place all Thunberg's names when Thunberg did not distinguish the difference in his own specimens.

This brief account will show that Thunberg's work on the South African *Proteaceæ* was poor. Not only did he fail to distinguish specific difference in many of his specimens, but he ignored the work of Niven and Brown published some years before his "Flora Capensis," which should have enabled him to distinguish at the least the genera represented in his herbarium.

Since this paper was read my attention has been drawn to a publication by Juel* on Thunberg's herbarium, in which the author refers the published names of Thunberg's plants to the present-day genus and species. As a list of the *Proteaceæ* collected and described by Thunberg is given by Juel, I have, with the permission of the editor, withdrawn the list which was prepared for the above short sketch.

* H. O. Juel "Plantæ Thunbergianæ. Arbeten utgifna med understod af Vilhelm Ekmans Universitetsfond—Uppsala," pp. 262-270. Uppsala, 1918.

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THE NINE-POINTS CIRCLE—A NOTE ON FEUERBACH'S THEOREM.

By the Rev. F. C. Kolbe, D.D., D.Lit.

With 5 *Text-figures.*

Read July 9, 1919.

[In the following paper I adopt the usual notation: ABC for the triangle; DEF for the feet of the medians; LMN for the feet of the angle-bisectors; PQR for the projections of ABC on the sides; I, etc., for the centres of the scribed circles; XYZ, etc., for the projections of I, etc., on the sides. Points analogous to DXLP I call *dxlp*.]

Three years ago I read a paper on the teaching of Geometry, illustrating my thesis by a number of proofs of properties of associated circles of the triangle. My thesis was that if preliminaries are rightly presented proofs can generally be expressed with great simplicity. It struck me then that Feuerbach's Theorem—viz., that the Nine-points Circle touches all the four scribed circles—ought to be capable of such a proof. The fact that nobody, as far as I knew, had found one seemed to me to be a hint that we had not struck on the right way of presenting it. A subsequent study brought me three or four such proofs, which I now bring forward. The last form of the proof is of the utmost simplicity; and if I were talking to geometricians only, my paper need not be more than ten or twelve lines in length. But I am still illustrating a

pedagogic theory, and I am also in hopes of helping teachers of geometry who do not venture to call themselves mathematicians. I am only an amateur myself. I shall therefore gain my end, without, I hope, losing the interest and helpful criticism of mathematicians, if I put forward the whole manner in which the right presentment developed in my mind.

The figure of the triangle with its scribed circles may be regarded as a network of straight lines touched by circles, or as a network of circles touched by straight lines. It is strange that there should be four circles and only three straight lines. The dualism which runs through all geometry makes us suspect that something is wanting. And there is. The missing link is the Nine-points Circle, and Feuerbach's theorem simply states that fact.

For the whole system may be regarded as a special case of a general problem—8 conics (in this instance circles) touching one another four and four. Four of the circles are quite isolated from each other: the other four (three of which have their centres at infinity, and are therefore straight) not only touch the rest, but also intersect one another.

Looked at from this point of view, the Nine-points Circle may, Hibernically speaking, be called the fourth side of the triangle. The more we consider the functions of this circle, the more inept does its "Nine-points" name appear. I wish we might call it the Link Circle. I myself, in my previous paper, suggested the name Orthocentric Twin-point Circle; but, besides being somewhat abstruse, this was obviously too heavy. Marsano called it the *circolo medioscritto*, and Mackay tried to naturalise the term in English; but this name classifies it with the scribed circles, whereas it should be classified with the sides.

If we consider this system in a state of flux, we see the Link circle grow smaller and smaller as the triangle approaches regularity. It reaches its minimum when it collapses on the in-circle, unites the points DLXP, etc., on each of the three sides, and brings all three *e*-scribed circles, already in contact with itself and the sides, into contact also with the in-circle, all in perfect symmetry.

At the first infinitesimal change from this regularity, we see the points DLXP, etc., separate in the proportion $DL.DP = DX^2$ (we shall presently see why), and we see the four scribed circles take an infinitesimal list each in its own direction: we see also the Link circle take a corresponding expansion *pari passu* in all these four directions. Each further infinitesimal side movement of the scribed circles is accompanied by an expansion of the Link circle in the same direction, and apparently of the same order of infinitesimal magnitude. The calculus could, I suppose, easily show the truth of our impression; but already, from the mental visualising, we see that Feuerbach's theorem is only "what we might have expected."

If we follow the movement till one of the vertices goes to infinity (Fig. 1), we see that it takes with it six of the Link

circle's nine points with its centre, and also two of the e-scribed circles. The figure now shows the Link circle (QDR) in its true light, classified with the sides as the fourth tangent to the two remaining scribed circles.

Throughout this movement one cannot but notice the perpetually recurring proportion $DL.DP = DX^2$. It is more than a *leit-motif;* it reminds us of the famous dactyl and spondee rhythm on which the slow movement of Beethoven's Seventh Symphony is built. The whole scheme might be called a geometrical symphony of mean proportionals.

It was this thought that led me to a new proof of Feuerbach's theorem. It seemed to me that an analysis of this pro-

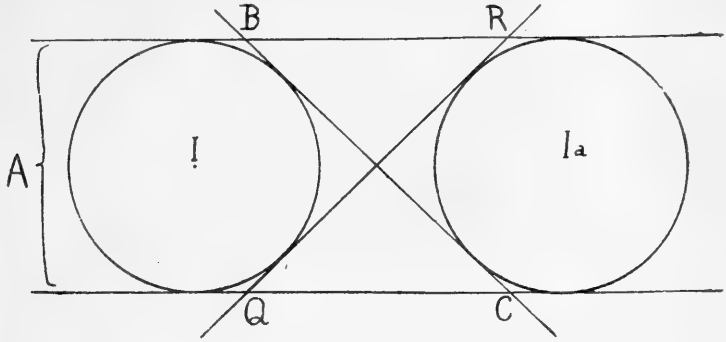


Fig. 1.

portion separately in the movement of the lines and of the circles might explain the power which the Nine-points Circle has of linking together into harmony all the asymmetries of the triangle and its associated circles.

Analysis of the mean proportion $dl.dp=dx^2$:—If a line-segment of constant length lx be moved upon a fixed line-segment dp, there are only two positions in which the mean proportion can hold, and these are simply reversed readings of each other. This is made obvious by revolving the segment lx to the position xl^1 (as in Fig. 2). The proportion $dl : dx :: dx : dp$ can be transformed into $dl : lx :: xl^1 : l^1p$, which, of course, reads both ways. The algebraic proof that no other position is possible is very simple. It can be seen with equal simplicity in this geometric figure. (Fig. 2) :—

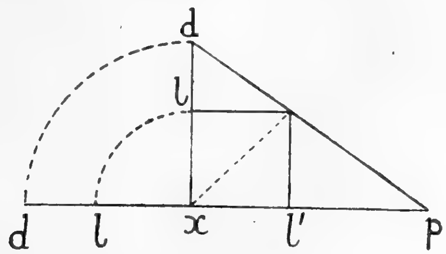


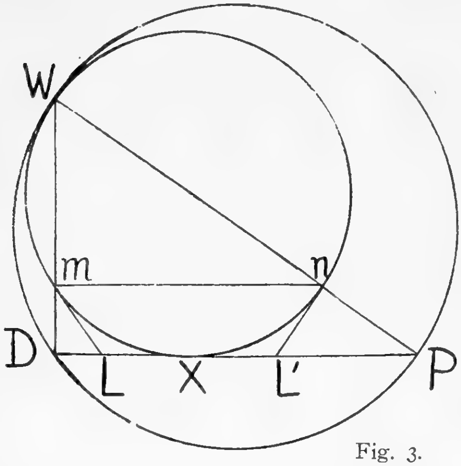
Fig. 2.

Obviously the only way of taking a piece off l^1p and adding it to dl and still retaining the proportion is to reverse the figure on the diagonal of the square.

It is equally obvious that x lies on opposite sides of the mid-point of dp in the two positions. If, therefore, we have occasion to compare a range of points DLXP with DlxP, knowing that lx=LX, and have given that Dl.DP=Dx^2 and also DL.DP=DX², we know that l coincides with L and x with X, if only we know that x and X are on the same side of the mid-point of DP.

Perhaps I might have assumed this elementary truth.

Relation of two circles in tangency.—If two circles touch, and a tangent be drawn to one of them meeting the other as a chord; if then the ends of the chord be joined to the contact point of the circles, and these joining lines mark off a new chord in the second circle; if also, at the end of this new chord, tangents



DL : Lm : : nL¹ : L¹P
i.e., DL : LX : : XL¹ : L¹P.
Or, as we have seen above, DL.DP=DX².

Fig. 3.

be drawn to meet the original chord, then that chord is divided in the proportion we have just been studying. When the figure is drawn, the proof is immediately obvious from the similarity of the triangles DLm and nL¹P.

These two very simple propositions are here set down merely for convenience. They are both of them interesting enough to have been taught long before students come to the associated circles. They do not, therefore, require proof from me, but only enunciation. But when they are enounced, the truth of Feuerbach's theorem becomes almost axiomatic.

Proof of Feuerbach's theorem:—

Given the triangle ABC with its Link circle and the in-circle.

Slide a circle equal to the in-circle along the chord DP until it touches the Link circle on the side nearer P. Join the point of contact with D, and where it cuts the inner circle draw a tangent, cutting DP in l. If the moving circle touches DP at x, we have Dl.DP=Dx^2.

Now DWP=C—B.

$\therefore$ $min=2$ (C—B).

and mix=C—B.

$\therefore$ lx subtends at i the same angle as LX does at I,

i.e., lx=LX,

and as x and X are obviously on the same side of the mid-point of DP, lx coincides with LX,

$\therefore$ the moving circle coincides with the in-circle. Ergo,

As precisely similar reasoning applies to the e-circles, this demonstrates Feuerbach's theorem.

Remarks.—If any ultra-conservative objects to sliding a circle (though every boy can trundle a hoop), it is quite easy to draw the circle in position, since the altitude of the centre and the two radii are known.

Although it is only a petty point in pedagogy, yet I may add that this line of proof gives an easy way of drawing the whole scheme. By drawing first two touching circles, the triangle and all the rest can be built up fairly accurately without any measurements, using only ungraduated ruler and compasses, and applying the set-square four times. Indeed, on occasion I have, though no great draughtsman myself, chalked on a blackboard for my class the whole figure, triangle, and five circles, quite freehand—a thing I should find impossible if I drew the triangle first.

I should not have mentioned this, except that it suggested to me a new and comprehensive proof. If, I thought, the figure can be built up from two circles and one proportion, why not also a demonstration?

Simultaneous proof of all the properties of the Link Circle.—Given a triangle and its in-circle, with PQR, DEF marked, and also O and TUV the mid-points of OA, OB, OC.

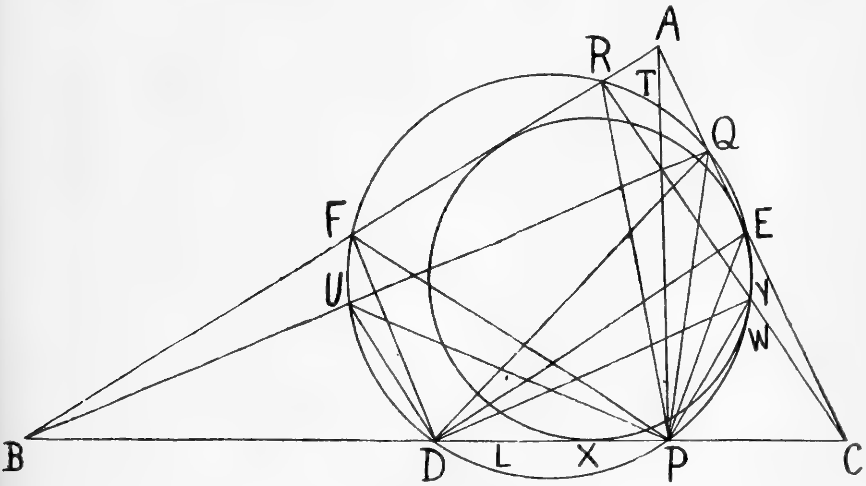


Fig. 4.

Draw a circle passing through D and P, and touching the in-circle at W.

This gives the proportion $Dl.DP=DX^2$
But $DL.DP=DX^2$

i.e., l coincides with L

∴ in this circle DP subtends the angle 2 LIX or (C—B) at the circumference.

But in the triangle it is known (or can easily be proved) that DEP, DFP, DQP, DRP, DTP, DUP, DVP, are all = (C—B).

∴ DEF, PQR, TUV are all on one circle which touches the in-circle, and which (since the reasoning applies equally) touches the *e*-circles also. Thus in one proposition we have proved the existence and all the chief properties of the Link or Nine-points circle, including Feuerbach's theorem.

This proof may seem clumsy and over-detailed, but it has the merit of showing how the asymmetries of the triangle keep in touch with the symmetrical stage. As the angle A moves, its departure from symmetry is measured lineally by the segment DP, and angularly by $B \sim C$. The proof, then, shows how all the eleven other points unite their angular variation with the linear variation of D and P.

For reference, I append the seven little proofs assumed above:—

(1) and (2) D and P.
(3) DFP=DFA—PFA=180°—A—2B=C—B.
(4) DEP=DEC—PEC=A—(180°—2C)=C—B.
(5) DRP=BRP—BRD=C—B.
(6) DQP=DQC—PQC=C—B.
(7) DUP=BUP—BUD=2C—(180°—A)=C—B.
(8) DVP=DVC—PVC=180°—A—2B=C—B.
(9) DTP.

If OP is produced to H so that PH=OP, and OD is produced to K so that DK=OD, then H and K are on the circumcircle; and since HK || DP, the angle at H is a right angle, and AK is a diameter.

∴ DTP=SAP=C—B.

Genesis of the proportion $DL.DP=DX^2$.

Hitherto I have been content with asserting the well-known relation in the triangle, $DL.DP=DX^2$.

The following consideration will show how important for our purpose it is to study it a little more deeply. If on a straight line we have a double mean-proportion range with a common segment dp, so that $dp.dl=dx^2=dx_a^2$ and $dp.dl^1=dx_b^2$ $=dx_c^2$, and if circles be drawn as in the accompanying diagram (Fig. 5), it is obvious that a circle through d, p, touching the i-circle will also touch the i_a-circle; and one touching the i_b-circle will also touch the i_c-circle. In one of these two circles dp will obviously subtend an angle$=2\ lix$, and in the other an angle$=2l^1i_bx_b$ (or their supplements). If, moreover, $l^1i_bx_b$ is

the complement of *lix* (*i.e.*, if its double is the supplement), it becomes clear that *dp* will subtend the same angle towards the same parts in both circles: that is, the two circles are identical. In this case, then, we have put four circles in such a position that one circle can be drawn touching all four. We are thus very near to Feuerbach's theorem, and it becomes interesting to see how the four circles can be thus placed.

The natural home of the mean proportional is the circle. If a point H moves towards a circle, and in each position a circle is

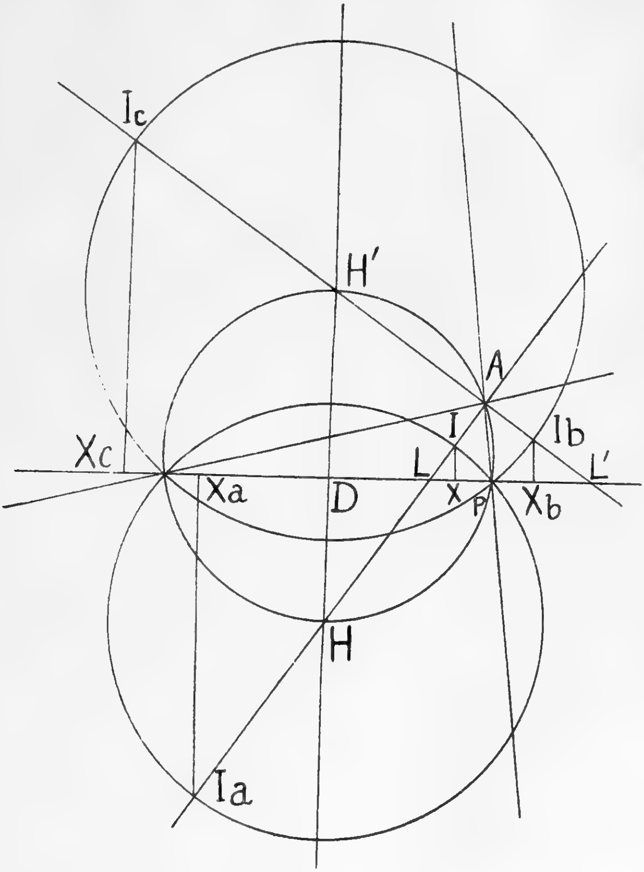


Fig. 5.

struck from it as centre through the two points of tangency, its whole pencil of chords is divided by itself and the four arcs in double mean proportion. A similar pencil is formed when H has entered the circle and strikes another circle on its symmetrical chord as diameter. These two pencils are, however, limited by the breadth of the original circle. But when H is on the circumference, a very surprising thing happens. Instead of the

supply of mean proportions vanishing, it is infinitely multiplied. If, now, a circle be described from H as centre through B, C, the ends of *any* chord symmetrical to H, then the two circles and the straight line BC divide in double mean proportion every chord through H; and this pencil extends to infinity on both sides. So that we have an infinite number of infinitely extended pencils. Since the same thing happens with H^1, the other end of the H diameter, it follows that both H and H^1 can choose the same chord BC, and thus concentrate their mean proportionals. Both sets can be projected on BC, together with a common segment, and we shall have the quadruple mean proportion we are looking for. Looking again at the original circle and its two auxiliaries struck from H and H^1 through B, C, we find (from the angles of the arcs on BC) that these two auxiliary circles are the locus on which lie all the in- and *e*-scribed centres of ABC, as A moves on the original circle. Since in each such position of A, HA, and H^1A are the bisectors of the angles at A, it follows that I, I_a, I_b, I_c, are the four points where HA and H^1A meet these auxiliary circles. Owing to this property, the whole scheme of the triangle, with its five principal associated circles, can be drawn *without any measurement at all.* Moreover, we see now that the quadruple mean-proportion range projected on BC has the relation, not only of the common segment DP, but also of the angle LI_bX_b being complementary to LIX—thus making it obvious that a circle through D and P touching one of the scribed circles touches them all.

We are now able to give an almost axiomatic proof of the existence of the Nine-points Circle along with the Feuerbach property.

Final Proof.

From the properties of the circum-circle in relation to the triangle ABC we have shown that there is a circle passing through D, P, which touches all four scribed circles.

For the same reason, there are circles passing through E, Q, and through F, R, touching the same four circles.

But only one circle can touch three given circles in the same sense.

Therefore these three circles are one and the same. That is, there is one circle passing through DEF and PQR, and touching all the in- and *e*-circles.

It is an exceedingly simple matter to add the other properties of this Nine-points Circle.

I think it will be conceded that this genetic way of regarding the question is more fruitful and suggestive than isolated proofs. And I think I may claim to have once more made good my thesis that in geometry suitable preliminary presentment almost supersedes proof by making intuition possible.

POISONING OF CATTLE BY FEEDING ON *PASPALUM DILATATUM* INFECTED WITH *CLAVICEPS PASPALI*.

By D. T. Mitchell, M.R.C.V.S.,
Senior Veterinary Research Officer, Maritzburg, Natal.

Read July 10, 1919.

The cultivation of *Paspalum* on an extensive scale as cattle feed in the Natal Province is of comparatively recent date, and although during the first few years the results justified the labour involved, in recent years it has been noted that in cattle which were allowed access to the *Paspalum* lands at a certain season, symptoms of inco-ordination of movement appeared in a large percentage of the animals, which symptoms disappeared slowly on changing the grazing ground to natural veld.

Serious outbreaks were reported from various parts of the province, and of these four were investigated.

Two of these occurred in Umvoti Country, one involving a large dairy herd, and the other a number of young stock, heifers and oxen. A third outbreak was reported from the Town Hill near Maritzburg, and clinical symptoms were found to be present in about 50 per cent. of the cows of a dairy herd. A number of young oxen and heifers at the Government Experimental Farm, Cedara, were inspected at an enquiry held there, and were found to be affected, showing characteristic symptoms, identical with those noted in previous outbreaks.

In all these cases symptoms had appeared in the cattle grazing on *Paspalum* pastures which were in the seeding stage, and in each case it was noted that a very large percentage of the heads of the grasses were infected with a fungus of the ergot type. Specimens were collected and submitted to Dr. Pole Evans, Plant Pathologist, who reported that the fungus present was *Claviceps paspali*, which had been noted in other parts of the world to produce a similar train of symptoms to those shown by the cattle in the affected herds under observation.

Of the species of ergot which are known to possess definite poisonous principles producing pathological or functional alterations in man and animals, the best known is *Claviceps purpurea*, the ergot which infects grain and rye grasses. The distribution of this fungus is very widespread, and its toxic properties have been recognized since the earliest times. Dissemination of the spores has been noted to be brought about by a species of beetle of the family *Carabidæ*, which collects the spores from the germinating sclerotia on the ground, and, on climbing up the tall

stems of the grass in order to get a high point to fly from, transmits the spores to the flowering heads of the grasses. Here a further development occurs. The pistil of the flower is attacked, and a mycelium is produced, growing as a mass of threads between the glumes. Conidia result from this mass, and a sticky substance, popularly known as honey-dew, is found, which materially assists in spore dissemination. The conidia are oval-shaped single cells, about 10 μ long, and show a cluster of granules near each extremity. These spores are transmitted from plant to plant in various ways by insects which feed on the honey-dew, by the movements of animals feeding in the infected pasture, and by wind causing contact of infected with healthy heads. In cattle grazing on *Paspalum* infected with ergot at this stage of its development it will be noted that hairs on the lips, cheeks, upper parts of the legs and along the abdomen are stuck together with this "honey-dew" exudation. From the mass of fungus threads the ripe sclerotia is formed.

The symptoms produced in cattle by feeding on ergotised grass vary according to the species of the infecting ergots. *C. purpurea* sets up a very definite train of symptoms, commencing with diarrhœa, lameness and stiffness in the limbs, affecting particularly the lower joints, associated with coldness and insensibility of the parts affected. This is followed by sloughing of the part and separation of the dead tissue usually in the neighbourhood of a joint. Portions of a limb may be sloughed off, for example, a toe, or in some cases the slough may involve the fetlock joint, resulting in separation occurring at this point. The ears and tail are frequently affected, partial or almost complete loss resulting.

Lesions may also be noted affecting the mucous membranes. Necrotic patches may appear on the buccal mucous membrane, and hyperæmia affecting the intestinal mucous membranes is of frequent occurrence. Abortion very frequently occurs in animals which are pregnant. There is little systematic disturbance except in complicated cases, and temperature is not elevated.

The American investigators, Brown and Ranck, carried out a series of animal tests in 1914-15 to determine whether *C. paspali* was capable of producing toxic symptoms in animals. Positive results were obtained by feeding guinea-pigs on the ripe sclerotia. Forty to 80 sclerotia, when fed daily, produced symptoms of hyperæsthesia, and after a few days inco-ordination of movement occurred, resulting in death after a period of complete paralysis. Commercial ergot extract (*C. purpurea*) was found to produce no distinct ill-effects. The administration of ¼ to ½ c.c. on four successive days produced only temporary sluggishness.

The ripe sclerotia given to calves *ad lib.* produced hypersensitiveness after two days, and later inco-ordination of move-

ment followed by frequent paroxysms, and later prostration and death.

In order to ascertain whether *C. paspali*, which is known to infect a high percentage of *Paspalum* lands in this country, would reproduce the symptoms in experimental animals which were observed in America in animals feeding on infected pastures, a series of experiments was arranged at the Veterinary Research Laboratory. Six animals were selected for the tests, and the ergot-infected *Paspalum* was collected from old *Paspalum* lands at the Government Experimental Station at Cedara. The method of collection was by stripping the infected heads by hand, the material resulting being a mixture of portions of the seed-heads and a fairly high percentage of ripe sclerotia. This material was fed within a few days after collection, in a mixture of bran and a small quantity of chopped lucerne.

From the experiments it was noted that feeding with quantities of infected heads of 9 lbs. to 12 lbs. produces a definite and diagnostic train of symptoms. The initial symptoms appeared in each case on the second day after the infected heads were fed to the animals, and were characterized by muscular tremors, hypersensitiveness, increased glandular secretion, and increases in respirations and pulse-rate. These symptoms were rapidly followed by inco-ordination of movement, lack of tone of the leg muscles, loss of appetite and constipation. Recovery was noted to commence about the fifth or sixth day, and from this onward slow improvement was shown. The animals on being turned out to graze were kept under observation for a further period, and it was noted that recovery could not be considered to be complete until at least two months had elapsed from the time the meal of infected heads was partaken of. Abortion did not occur. One animal calved normally three months later.

A short description of the disease as it appears under natural conditions in the Province of Natal is here given, together with suggestions for preventive measures to be adopted.

Cause.

The causal agent of ergotism in this Province has been demonstrated to be *Claviceps paspali* associated with *Paspalum* lands which have been established for some years. So far no cases of true ergotism due to ingestion of grass or grain infected with *C. purpurea* have been reported, and it is doubtful whether this latter fungus exists in any part of the Province to such an extent as to produce clinical symptoms in animals.

Distribution.

The infection is very widespread, in fact, may be looked upon as general throughout the midland portion of the Province.

Outbreaks which have been reported were limited to the midlands. No cases were reported from the northern portion adjacent to the Drakensberg range or from the coastal belt. In the latter area, however, this is understood as, owing to the absence of frosts and to the humid conditions which exist for the greater part of the year natural grazing is plentiful, and the necessity for providing additional grazing during the winter months, when the veld grazing is scanty, is not so important. *Paspalum* has only been cultivated to a limited extent in this area. In the midlands the cultivation of *Paspalum* had been undertaken on a fairly extensive scale in former years, and in seasons which favour the growth of the fungus it is almost impossible to find an area under this grass which is not grossly infected. Even along the roadsides, where accidentally sown plants are to be found, these are almost constantly found to be infested.

Occurrence.

The occurrence of the condition among cattle feeding on *Paspalum* lands varies each year, and is chiefly dependent on the extent to which the grass is infected. Like most fungi, warm humid conditions favour development and dissemination, and so, as is to be expected, the percentage of infected *Paspalum* heads in a pasture is very much greater in seasons where a mild winter is followed by frequent rains during the spring and early summer. The stage of growth at which the fungus is able to set up the characteristic symptoms is limited to the period when the sclerotia are ripe, which coincides with the ripening of the grass seeds. During the "honey-dew" period the cattle appear to be able to eat the infected grass with impunity. It was noted that cattle feeding on *Paspalum* on which ripe sclerotia were present evinced a special fondness for the high-standing diseased heads after a meal of the lower and more succulent foliage had been collected. This point has also been commented upon by Brown and Ranck. Symptoms are usually developed about a week after exposure in the infected pasture, and the percentage of animals which show clinical symptoms varied from 5 to 60 per cent. in the outbreaks investigated.

Animals Affected.

The condition was only noted to occur in cattle, and young stock of from 14 months to two years appeared to be more susceptible than adult cattle. Horses, donkeys, sheep and goats grazed on the infected grass without developing any clinical symptoms. This apparent immunity may to some extent be due to the different method of grazing which is adopted by these animals, by which little of the infected heads would be collected. No fondness for diseased heads such as was observed in cattle was noted in these animals.

Symptoms.

The symptoms in the affected animals vary in intensity from a slight inco-ordination of movements to complete paralysis. Hyperæsthesia and increased respirations were not so marked in the cases which occurred under natural conditions as were noted in those produced experimentally.

In the majority of instances the natural cases were comparatively mild; the symptoms shown consisted of staring coat, high-stepping movement of the front legs in walking, defective vision indicated by an absence of any attempt to avoid holes in the ground or obstacles, occasional stumbling, lateral swaying of the hindquarters, and a general lowering of muscular tone. Appetite was unimpaired in the early stages, but later there was loss of appetite, and in consequence the animal had a "tucked-up" appearance. The most acute cases were seen among some 18-months-old oxen which had been feeding on infected grass for some weeks. Here cases of partial paralysis were noted, and these affected animals exhibited marked symptoms of hyperæsthesia, hurried respirations, and a rapid thready pulse.

Mortality.

A few cases of deaths from the condition were reported, but in none of the outbreaks personally investigated did any mortality occur. This may have been due to the fact that in these cases the owners were advised to remove the animals at once and provide good nursing for badly affected animals, but in general it may be taken that in uncomplicated cases the mortality is almost negligible. The resulting loss of condition is the economic factor most to be considered, and, though clinically affected animals recover from the acute symptoms fairly rapidly, it requires a considerable time on a good nursing diet to recover from the effects of the intoxication, and the animals' general physique, especially in growing animals, suffered in consequence.

Treatment.

The treatment which was found to give most rapid results, after the necessary removal from the *Paspalum* lands, consisted of a saline purge followed by a few days' rationing on green lucerne or barley, the idea being merely to prevent further ingestion, and to assist in elimination of the unabsorbed toxic elements in the digestive tract.

Prophylactic measures consist of reaping and collection of the grass during the flowering season, at which time the material collected from the lands may be fed to cattle with perfect safety. Burning of unreaped lands during the winter will have the effect of destroying most of the resting forms of the fungus, but this procedure is not to be recommended on account of harmful

effect of the fire on the grass roots. Heavy stocking at the commencement of summer before the flowering season will be found to be effectual. By this means the formation of flowering heads is prevented and infection of the pasture is rendered impossible.

In the outbreak at Cedara, which involved a herd of young oxen, a number of deaths from red-water occurred after recovery was almost complete. The grazing ground on which these animals ran was red-water veld, but as the animals had been reared in the area, and as no cases occurred in cattle of a similar age grazing in adjoining camps, it was considered that the mortality was due to a breakdown in immunity resulting from lowered vitality due to ergot intoxication. The absence of abortion in pregnant animals contracting the disease under natural conditions, and also of any symptoms of necrosis or sloughing, was noted in the outbreaks reported and investigated. The condition does not give rise to any immunity or distaste for the fungus, and animals again allowed access to lands in which the infection is present during the same or succeeding year will develop all the characteristic symptoms.

STAR STREAMS.

By H. E. Wood, M.Sc., F.R.Met.S.

(*Title only.*)

THE SOILS OF THE PRETORIA DISTRICT.

By B. de C. Marchand, B.A., D.Sc.

(*Title only.*)

ON SOME PHYTOGEOGRAPHICAL BOUNDARIES IN THE COUNTRY BETWEEN THE GREAT FISH RIVER AND VAN STADEN'S MOUNTAINS.

By Prof. S. Schönland, M.A., Ph.D., F.L.S.

(*Title only.*)

SOME NOTES ON THE DISTRIBUTION OF THE GENUS *ALOE* IN SOUTH AFRICA.

By I. B. Pole-Evans, M.A., D.Sc., F.L.S.

(*Title only.*)

THE GENUS *BORBONIA* LINN. (LEGUMINOSÆ).

By E. P. Phillips, M.A., D.Sc., F.L.S.,
Division of Botany, Pretoria.

With 1 Map and Plates XXXIV-XXXVIII.

Read July 11, 1920.

The genus Borbonia was founded by Linnæus in 1737, and in his "Species Plantarum" he described four species, and again described the genus in 1743. The first important publication on the genus appeared in De Candolle's "Prodromus," where eleven species are described, nine of which are still recognised. Bentham in 1843 described two new species, *B. latifolia* and *B. complicata*, but it was not until the publication of the "Flora Capensis" that the genus was again monographed. Harvey gives a key to, and describes 13 species, and brings together the synonymy, and I have not had any occasion, after examining all the available material in the South African herbaria, to sink any of the species described by him.

The genus *Borbonia* is closely related to *Rafnia,* and Bentham and and Hooker distinguish the two genera as follows:—

Borbonia: Calyx-lobes equal, acute or pungent. Vexillum villous. Legume acute. Shrubs or suffrutices with many-nerved leaves.

Rafnia: The lower calyx-lobe smaller than the others. Petals glabrous. Legume acute. Shrubs or suffrutices with one-nerved leaves.

Harvey in his Key also uses the character of the calyx in separating *Borbonia* from *Rafnia.* In the material examined I find, however, that in two species, namely, *B. crenata* and *B. parviflora*, the calyx-lobes are not equal, but that the abaxial lobe is longer than the others, while in *B. leiantha* all the petals are over glabrous. The leaves especially in texture and venation at once determine into which genus a species should go. All the species of *Borbonia,* with the exception of *B. villosa,* have very rigid leaves with three to many nerves, while in *Rafnia* the leaves are leathery, not firm and rigid, and have only a midrib.

A few species of *Aspalathus,* as *A. corymbosa* E. Mey and *A. tenuifolia* D. C., belonging to the section Terminales, have simple leaves, but in these the pods are obliquely ovate at the base, a character which at once distinguishes them from species of *Borbonia,* whose pods are equal at the base. In *B. mono-*

sperma, however, the pod resembles that of an *Aspalathus.* The species named by Marloth* *B. pinifolia* (Pl. XXXV, Fig. A) belongs to the above section of the genus *Aspalathus.*

The species of *Borbonia* are essentially plants of the Western Province, and more than half the number of known species are found in the Ceres, Tulbagh, Cape and Caledon Divisions. Two species, namely, *B. villosa* and *B. multiflora,* have not been recorded further south than Porterville Road, near Tulbagh, and are apparently confined to the mountains of Calvinia, Clanwilliam, Piquetberg, Ceres and Tulbagh. *Borbonia lanceolata* and its varieties has the widest distribution. A well-defined variety (var. *robusta*) has been recorded by Pearson from the Khamiesberg, in South-West Africa, and from Ceres. The species then appears in the Western and South-Eastern coastal districts to the Albany Division. No records are known of the occurrence of any species north of the Langeberg Range, though it is very probable that the genus will be met with on the Zwartbergen when this range is better explored.

My thanks are due to Mr. J. Hutchinson, of Kew, for sending me descriptions of four species (*B. monosperma, latifolia, complicata* and *alpestris*) which were not represented in any South African herbarium. He also furnished me with records of the species from the Kew Herbarium, which has enabled me to extend the geography.

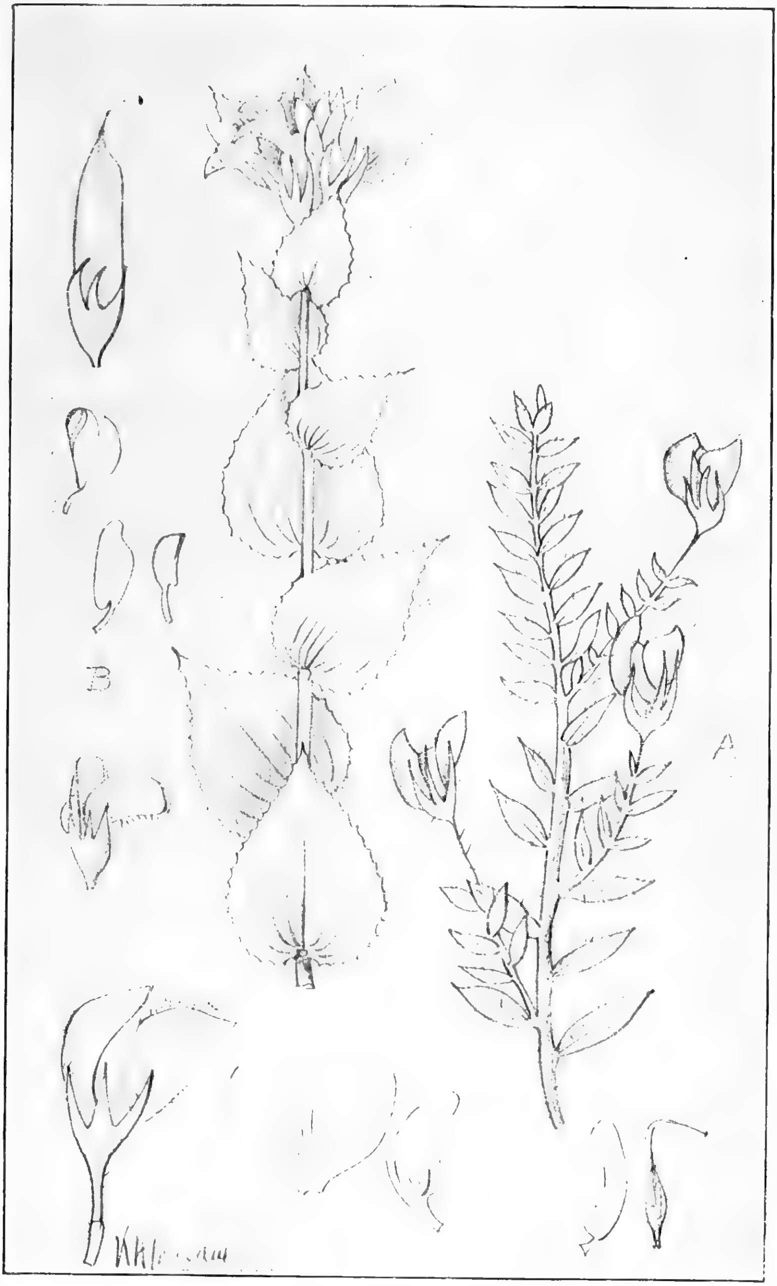
Borbonia Linn.

Calyx lobes equal, rarely the abaxial lobe longer, acute or pungent. *Petals* clawed; the vexillum, sometimes also the alæ and carina, hairy, very rarely all glabrous. *Stamens* monadelphous with anthers of two different sizes. *Ovary* sessile, rarely subsessile, one to many seeded; style arcuate; stigma terminal and capitate. *Legume* linear or lanceolate, compressed, acute, equal at the base, very rarely obliquely-ovate at the base; valves coriaceous.

Shrubs or suffrutices, rarely decumbent, glabrous or rarely villous. Leaves simple, entire, usually pungent at the apex and often cordate, amplexicaul or perfoliate at the base, glabrous or rarely villous, rigid, many-nerved, with smooth or toothed margins. Flowers yellow, often turning reddish with age, solitary, shortly racemose or subcapitate or subumbellate, axillary or terminal. Bracts and bracteoles often setaceous.

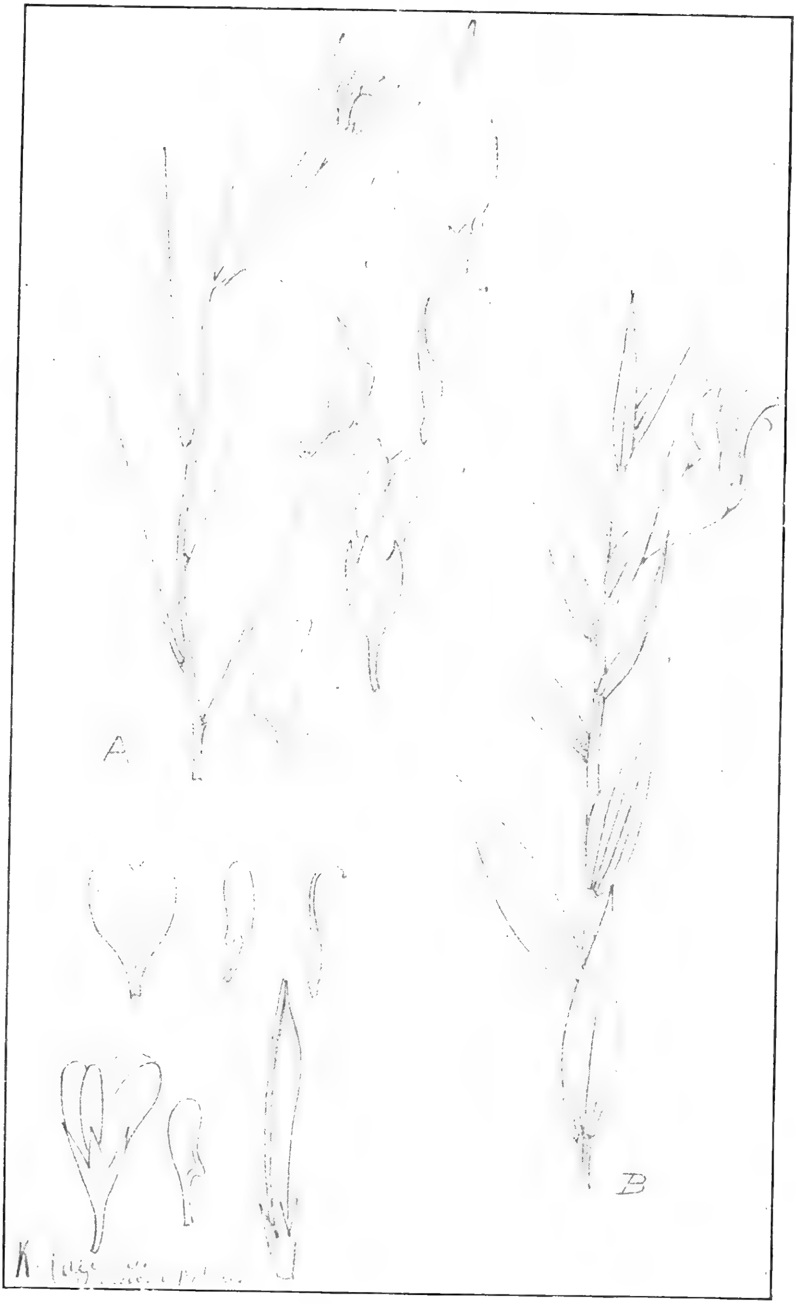
Leaves more or less densely villous; branches slender, diffuse, laxly leafy. — 1. *villosa.*
Leaves not villous.

* Trans. Roy. Soc. S.A., II., p. 238.

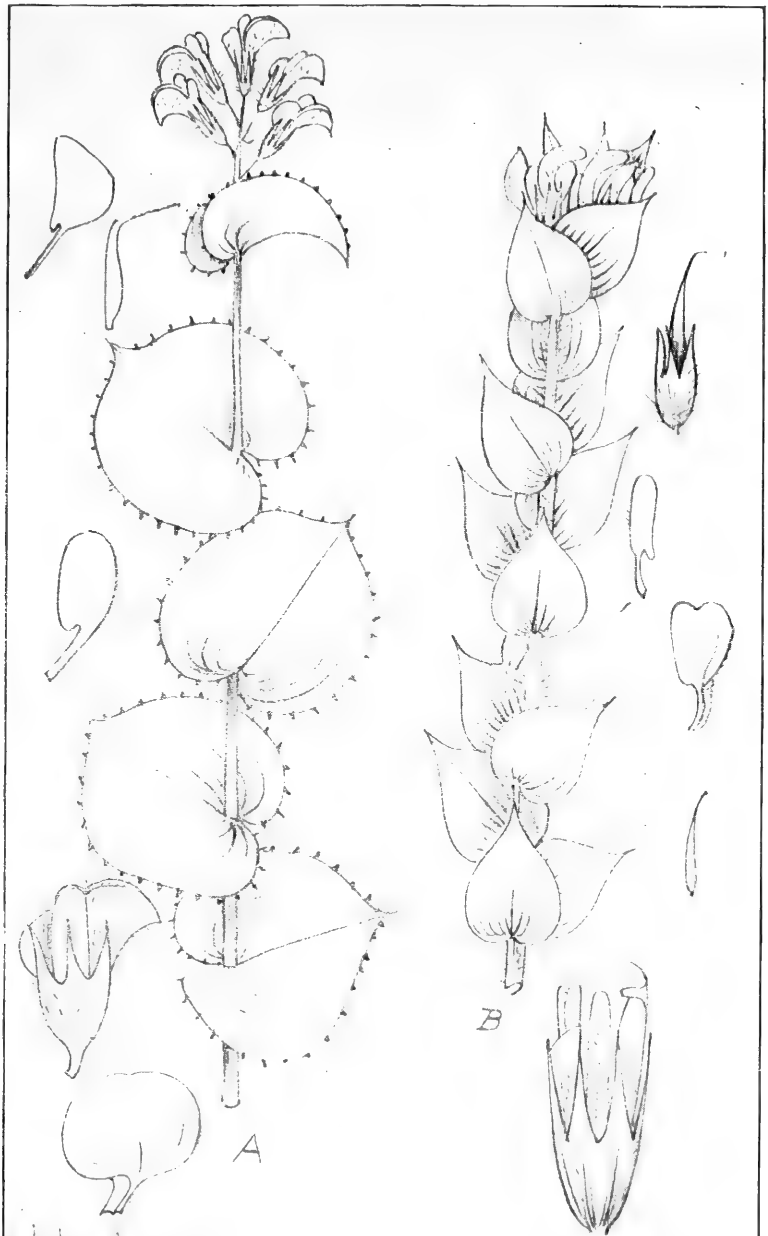


A. *B. villosa*, Harv.
B. *B. parviflora*, Lam.

E. P. Phillips.—The Genus *Borbonia*, Linn. (Leguminosæ).



A. *Aspalathus* (*Borbonia pinifolia*, Marl.).
B. *B. lanceolata*, Linn.



A. *B. multiflora*, Phill.
B. *B. cordata*, Linn.

Flowers borne on short axillary shoots, with filiform pedicels 1.5-2 cm. long; stems prostrate. 2. *trinervia.*

Flowers not borne on short axillary shoots; pedicels neither long nor filiform.

Leaves narrowly lanceolate.

Leaves 3-nerved; pods 1-seeded. 3. *monosperma.*

Leaves 5-more-nerved; pods more than 1-seeded.

Leaves narrowly lanceolate, lax; calyx glabrous. 4. *lanceolata.*

Leaves dense; calyx villous. 5. *barbata.*

Leaves orbicular or ovate.

Leaves amplexicaul or perfoliate.

Calyx-lobes shorter than the tube, glabrous or nearly so.

Leaves perfoliate with crenulate margins; inflorescence few-flowered. 6. *perforata.*

Leaves amplexicaul, with jagged margins; inflorescence many-flowered. 7. *crenata.*

Calyx-lobes as long or longer than the tube, hairy.

Peduncles 1-3 flowered; branchlets rather slender. 8. *undulata.*

Peduncles 7-8-flowered; branches rather stout and rigid. 9. *multiflora.*

Leaves not or only semiamplexicaul, more or less cordate at the base.

Branches glabrous.

Branches angular; leaves 2.3-5 cm. long.

Vexillum silky-pubescent outside.

Leaves broadly orbicular-ovate; inflorescence sub-capitate, many-flowered. 10. *latifolia.*

Leaves lanceolate-ovate; inflorescence about 6-flowered. 11. *parviflora.*

Vexillum glabrous outside. 12. *leiantha.*

Branches not angular.

Leaves 1.2 cm. long or less. 13. *alpestris.*

Leaves over 1.2 cm. long, rounded-ovate. 14. *complicata.*

Branches villous, leaves with smooth margins. 15. *cordata.*

	Calvinia.	Clanwilliam.	Piquetberg.	Malmesbury	Ceres	Tulbagh	Paarl.	Cape	Stellenbosch	Worcester	Caledon	Bredasdorp.	Swellendam.	Riversdale.	Mossel Bay.	George.	Knysna	Humansdorp.	Uitenhage	Port Elizabeth.	Alexandria.	Albany.	Robertson.
villosa		×			×	×																	
trinervia					×						×		×	×	×								
monosperma																							
lanceolata					×	×	×	×	×	×	×	×		×	×	×			×	×		×	
barbata								×															
perforata						×		×			×		×										
crenata					×	×	×		×														
undulata						×	×	×															
multiflora	×	×	×			×																	
latifolia											×												
parviflora		×				×	×	×	×	×	×												
leiantha											×												
alpestris																							×
complicata			×																				
cordata			×	×		×		×															

1. *B. VILLOSA* (Harv., "Fl. Cap.," ii. 28). (Pl. XXXIV, Fig. A.) A prostrate creeper. *Branches* terete, villous. *Leaves* 1.2-2 cm. long, 3-5 mm. broad, lanceolate, more rarely elliptic, acute, subacuminate, with smooth margins, distinctly 3-nerved, villous. *Flowers* usually solitary on short axillary shoots, sometimes 2-nate. *Pedicels* .6-1.7 mm. long, villous, articulated about the middle. *Calyx-tube* 2.5 mm. long, campanulate, loosely villous; lobes 5 mm. long, ovate, long acuminate, acute, villous without; alæ 7 mm. long, 2.5 mm. broad, oblong, rounded above, shortly stalked; carina 8 mm. long, 3.5 mm. broad, plano-convex in outline, shortly stalked. *Anthers* of 2 sizes; 5 are .5 mm. long, orbicular in outline; 5 are 1 mm. long, oblong in outline. *Ovary* stalked, 3 mm. long, gradually passing into the arcuate style, villous; stalk 1.5 mm. long; stigma capitate. *Fruit* up to 1.5 cm. long, somewhat falcate, 2-4-seeded, villous.

Clanwilliam Division: Cedarberg Mountains, at Krakadouw Pass, *c.* 3,000 ft., October, *Bolus* 8967! Ceres Division: Gydouwberg, Cold Bokkeveld, 5,800 ft., Jan., *Schlechter* 10043!, near Klyn Vlei, Cold Bokkeveld, 4,500 ft., Jan., *Schlechter* 10197!;

Witsenberg and Schurfdeberg, Dec., *Zeyher* 437! Tulbagh Div.: Great Winterhoek, Dec., *Guthrie* 4183!; Sneeuwgat Valley, Great Winterhoek, *c.* 4,000 ft., Nov.-April, *Phillips* 1738! and in *Herb. Musei Austro-Afric.* 11196!

2. *B. TRINERVIA* (Thunb., "Prodr.," p. 122). (Pl. XXXVIII, Fig. A.) *Branches* glabrous. *Leaves* 1.2-2.5 cm. long, 1-3.5 mm. broad, lanceolate, acuminate, acute, pungent, prominently 5-ribbed beneath, smooth above, glabrous, with the margins remotely and minutely serrated and thickened. *Flowers* solitary, rarely 2-nate, terminal on short axillary shoots. *Pedicels* 1.5-2.5 cm. long, slender, articulated 3 mm. below the calyx. *Bracts* 4 mm. long, linear-lanceolate, acuminate, acute. *Calyx-tube* 4 mm. long, campanulate, glabrous; lobes 4 mm. long, ovate, acuminate, acute, glabrous. *Vexillum* 9.5 mm. long, 8.5 mm. broad, obovate, rounded above, with a short claw, pubescent without; alæ 9.5 mm. long, 3.5 mm. broad, oblong, rounded above with a claw 2.5 mm. long; carina 8 mm. long, almost plano-convex in outline, obtuse, with a claw 2.5 mm. long. *Anthers* of 2 different sizes and shapes: the smaller .5 mm. long, orbicular in outline; the larger .75 mm. long, oblong. *Ovary* subsessile, 6 mm. long, 1 mm. broad, compressed, glabrous; style 4 mm. long, arcuate; stigma capitate. *Fruit* 1.7 cm. long, .4 cm. broad, lanceolate, subacute, glabrous. "Fl. Cap.," ii. 28

Ceres Div.: Koude Bokkeveld, 4,500 ft., Jan., *Schlechter* 10194! Swellendam Div.: Swellendam, Nov., *Zeyher* 1214!; subalpine places near Gauritz Hoogte, *Mund* 81!; Ruggens near River Zonder Einde, *c.* 600 ft., Oct., *Galpin,* 3912! Steinbok River, 800 ft., Dec., *Schlechter* 9779!. Riversdale Div.: near Riversdale, *c.* 800 ft., Nov., *Schlechter* 1884! Dec., Pappe 6!. Caledon Div.: Houw Hoek and Caledon, *MacOwan* 2830! and *in Herb. Norm. Austro-Afric.* 721!. Mossel Bay Div.: Between Zout River and Duyker River, Nov.; *Burchell,* 6386; between Duyker River and Gauritz River, Nov., *Burchell* 6378.

3. *B. MONOSPERMA* (D.C., "Prodr.," ii. 120). *Shoots* erect, densely leafy, glabrous, slightly angular below the leaves. *Leaves* 3-4 cm. long, 4-5 mm. broad, linear-lanceolate, shortly acutely acuminate, broadly obtuse at the base, prominently 3-nerved below, glabrous (pilose ciliate when quite young). *Flowers* axillary, solitary; pedicels 1 cm. long, long-pilose. *Calyx-tube* turbinate, 2 mm. long, with a few long slender hairs; lobes subulate from a broader base, nearly as long as the tube, with a few hairs. *Corolla* about 6 mm. long. *Fruit* 7 mm. long, obliquely-ovate, flattened, acute, glabrous, 1-seeded. "Fl. Cap.," ii. 28.

South Africa: without locality *Bowie in Herb. Kew.*

4. *B. LANCEOLATA* (Linn. Sp. 994). (Pl. XXXV, Fig. B.) *Branches* terete or obtusely angled, glabrous. *Leaves* 1-3

cm. long, 1-6 mm. broad, lanceolate, acuminate, acute, pungent, prominently 5-8-ribbed beneath, smooth above, glabrous, with the margins thickened and smooth. *Flowers* terminal, solitary, 2-nate, or in a short 10-flowered raceme. *Pedicels* .3-1.6 mm. long. *Bracts* when present setaceous. *Calyx-tube* 4.5 mm. long, campanulate, ribbed, glabrous; lobes 5.5 mm. long, ovate, acuminate, acute, ribbed. *Vexillum* 1.75 cm. long, 1.15 cm. broad above, obovate, emarginate above, shortly clawed, densely pilose; alæ 1 cm. long, .5 mm. broad, plano-convex in outline, pilose, with a linear claw 6 mm. long; carina densely pilose. *Fruit* 3-4 cm. long, 4 mm. broad, linear, acuminate, glabrous. "Fl. Cap.," ii. 28.

Riversdale Division: near Riversdale, 700 ft. *Bolus*!; Corente River, Nov., *Muir* 62!. Caledon Div.: near Caledon, Nov., *Pappe* 3!. Worcester Div.: Hex River Valley, 1,500 ft., Jan., *Tyson* 742!. Stellenbosch Div.: Hottentot's Holland Mountains, *Zeyher* 1213!, *Pappe* 3!. Cape Div.: Kenilworth, Dec., *Bolus* 7286!; Rondebosch, Nov., *Zeyher* !; Wynberg, *Pappe* 3!, March, *Ecklon and Zeyher* 134!; Claremont Flats, *Schlechter* 98!; plains at Kommetje near Simonstown, *c.* 100 ft., Nov., *Galpin* 3916!; Zwatrivier, Nov., *Pappe*!; Koeberg, Nov., *Pappe* 3!. Mossel Bay Div.: Ruyterbosch, *Miss Britten* 124!. George Div.: George, Jan., *Mrs. Patterson* 1224!. Port Elizabeth Div.: Van Staden's River Mountains, 100 ft., Jan., *Bolus,* 1606!; Van Staden's, near Port Elizabeth, Sept., *Mrs. Patterson* 174!. Uitenhage Div.: Witteklip, 400 ft., Jan., *Bolus* 13332!, *MacOwan* 1099!; Uitenhage, Oct., *Ecklon and Zeyher* 336!; Krakahamma, Jan. to March, *Zeyher,* 1212!. Albany Div.: Rondebosch, Dec., *Hutton in Herb. Albany Mus.!*

var. *gracilis* (Harv., "Fl. Cap.," ii. 28). Differs from the type in the slender habit and the 3-nerved leaves.

Ceres Div.: Gydouw, near Ceres, 3,200 ft., Jan., *Bolus*!; Matroosberg, near Laken Vlei, 3,500 ft., Jan., *Phillips* 1931! and *in Herb. Musei Austro-Afric.* 11731! Tulbagh Div.: Tulbagh Waterfall, 150 ft., Nov., *Schlechter,* 9061!

var. *robusta,* Phillips var. nov. *Suffrutex* 50-60 cm. altus. *Folia* 3-nervigera.

South-West Africa: Middle of Khamiesberg plateau, N.E. of Leliefontein, 4,000 ft., Jan., *Pearson in Percy Sladen Memorial Exped.* 6346!

This is a very distinct variety. It agrees with var. *gracilis* in having 3-nerved leaves, but is a much-branched shrub 18 in. high.

var. *villosa,* Phillips var. nov. Ramuli et calyces villosi.

Caledon Div.: near Elim, *c.* 1,000 ft., Dec., *Bolus*! Port Elizabeth Div.: Port Elizabeth, Nov., *Kemsley in Herb. Albany Mus.* 1101! Bredasdorp Div.: Mtns. near Koude River, 800 ft., *Schlechter* 9732!

This variety links up *B. lanceolata* with *B. barbata*. *Kemsley* 1101 has the habit of the latter, but differs in having lanceolate and not ovate-acuminate leaves. *Schlechter* 9732 and *Bolus* (from Elim) have the habit of *B. lanceolata*, but the branches and calyx are villous.

The following additional localities have been given me by Mr. Hutchinson, but as I have not seen the specimens, some of which may belong to the above varieties, I have kept them separate.

South Africa: Without locality, *Drège, Harvey* 769, 767, *Sieber, Zeyher* 365, 364, *Ecklon* 1212.

Ceres Div.: Upper western slopes of Sneeuwkop, Dec., *Pearson and Pillans in Percy Sladen Memorial Exped.* 5764; lower southern slopes, *Pearson in Percy Sladen Memorial Exped.* 5873. Cape Div.: Chapman's Bay, Dec., *MacGillivray* 496; Diocesan College Ranges, March, *Wolley-Dod*, 909, near Cape Town, *Burchell* 4478. Caledon Div.: River Zonder Einde, *Burchell* 7542; near Zoetemelks River, *Burchell* 6672; Hottentot's Holland Mountains, *Ecklon* 1213. Paarl Div.: Klein Drakenstein Mountains, *Drège* a.

5. *B. BARBATA* (Lam., Dict., 2, p. 436. Ill., t. 610. f.2.) (Pl. XXXVIII, Fig. B.) A shrub 1.1 m. high. *Branches* villous. *Leaves* 2-2.5 cm. long, 3-4 mm. broad near the base, ovate, long-acuminate, acute, pungent, 9-13-nerved, glabrous or scantily pilose, with the margins thickened and smooth. *Inflorescence* capitate, partially hidden by the upper leaves. *Calyx-tube*, 6 mm. long, campanulate, pilose; lobes 6 mm. long, long-acuminate from an ovate base, acute, villous. *Vexillum* 1-5 cm. long, 8 mm. broad, elliptic, densely pilose without, with a linear claw 5 mm. long; carina 1.5 mm. long, plano-convex in outline, densely pilose, with a linear claw 6 mm. long; alæ 2.6 mm. long, lanceolate, rounded above, densely pilose, with a linear claw 6 mm. long, *Ovary* 5 mm. long, pilose at the base, gradually passing into the arcuate style; stigma small, capitate. "Fl. Cap.," ii. 27

Cape Division: Table Mountain, Kloof by Tokai Zigzag, Nov., *Wolley-Dod*, 1939!; nek between Table Mountain and Devil's Peak, *c.* 2,000 ft., Nov., *MacOwan in Herb. Austro-Afric.* 535! and *in Herb. Bolus*, 3361!; slopes above Camp's Bay, *Marloth* 7911!; Table Mountain, Nov., *Ecklon and Zeyher* 1211!, *Pappe* 2!; foot of Table Mountain, *Alexander;* mountains above Simon's Town, frequent, Dec., *MacGillivray*.

6. B. PERFORATA (Thunb., "Prodr.," p. 122). (Pl. XXXVII, Fig. A.) A decumbent plant. *Shoots* from an underground rootstock. *Branches* glabrous. *Leaves* 1-2.7 cm. long, 1-2.4 cm. broad, orbicular, perfoliate, glabrous, toothed and long-ciliate on the margins. *Inflorescence* racemose, 3-6-flowered, rarely solitary; peduncle glabrous. *Bracts* 3.5 mm. long, setaceous,

glabrous; bracteoles 1 mm. long, ovate, acute, glabrous. *Vexillum* 7 mm. long, 3.5 mm. broad, obovate, pubescent without, with a linear claw 2.5 mm. long; carina 6 mm. long, 2 mm. broad, plano-convex in outline, with a linear claw 2.5 mm. long. *Anthers* orbicular in outline; the larger .6 mm. long; the smaller .3 mm. long. *Ovary* 4 mm. long, terete, glabrous; style arcuate; stigma capitate. *Fruit* 1-11 cm. long, 2.5-4 mm. broad, oblong or linear-oblong, acute, glabrous. "Fl. Cap.," ii. 30

Tulbagh Div.: near Tulbagh Kloof, Sept., *Bolus*!; slope of the Winterhoek, *c.* 1,100 ft., Nov., *Bolus*!; Tulbagh, 1,000 ft., Febr., *Schlechter* 7465! Jan., *Marloth* 1718! Winterhoekberg, *Ecklon and Zeyher* 1205!; Great Winterhoek, 3-4,000 ft., Nov., *Phillips* 1732!.

Caledon Div.: Palmiet River, near Grabouw, 700 ft., Dec., *Bolus* 4134!; between Donker Hoek and Houw Hoek Mountains, March, *Burchell* 8014. Cape Div.: Camps Bay without collector one of two specimens on a sheet *in Herb. Musei Austro-Afric.*!; near Cape Town, Jan., *Burchell,* 418, Camps Bay, *Harvey* 232. Swellendam Div.: Grootvadersbosch, near Swellendam, 800-1,200 ft., *Mund* 29.

7. *B. CRENATA* (Linn. Sp. 994). (Pl. XXXVII, Fig. B.) Young branches sparsely pilose, becoming almost glabrous. *Leaves* 1.3-4 cm. long, 1.2-3.5 cm. broad, ovate, rounded above or shortly acuminate, pungent, amplexicaul, the mid-rib and lateral veins prominent, glabrous, with a distinct callous-toothed margin. *Inflorescence* racemose, 8-20-flowered, terminal, peduncled; the peduncle usually hidden by the uppermost leaf; pedicels 3 mm. long, glabrous, terete; bracts and bracteoles deciduous. *Calyx-tube* 6 mm. long, campanulate; lobes 1 mm. long, ovate, acute, ciliate; the anterior lobe 2 mm. long. *Vexillum* .5 mm. long, 9 mm. broad, obovate, villous without, with a channelled claw 5 mm. long; alæ 7.5 mm. long, 3 mm. broad, oblong, rounded above, with a linear claw 5 mm. long; carina 6.5 mm. long, 4 mm. broad, plano-convex in outline, with a linear claw 5 mm. long. *Larger anthers* 1 mm. long, oblong in outline; the smaller .5 mm. long, orbicular in outline. *Ovary* 6 mm. long, 1 mm. broad, linear, merging into the arcuate style; stigma capitate. *Fruit* 2.5-2.7 cm. long, 5-7 mm. broad, lanceolate in outline, acute, glabrous, with the anterior edge slightly more convex than the posterior. "Fl. Cap.," ii. 30. *Bot. Mag.,* t. 274.

Ceres Div.: Koude Bokkeveld, Skurfdebergen, near Wageboom's River, 5,000 ft., Jan., *Schlechter* 10167! Tulbagh Div.: Slopes at foot of the Winterhoek, 1,100 ft., *Bolus* 5008!; Jan., *Marloth* 1717! Tulbagh Waterfall, Oct., *Bolus*!; Witsenberg, Oct., *Pappe* 11!; Steendal, Oct., *Pappe!;* Witsenberg Range, near Tulbagh, April, *Burchell* 8709. Paarl Div.: Du Toit's Kloof, *Drège*. Stellenbosch Div.: Stellenbosch, *Miss Duthie*, 240!

8. *B. UNDULATA* (Thunb., "Prodr.," p. 122). A prostrate plant. *Branches* dark red (Phillips), pilose becoming almost glabrous. *Leaves* .9-2.5 cm. long, rounded and mucronate at the apex, amplexicaul at the base, pilose above and beneath, becoming almost glabrous in old specimens, with the margins rough or sometimes almost smooth. *Inflorescence* a 2-5-flowered peduncled raceme; peduncle pilose. *Pedicels* 4 mm. long, terete, pilose. *Bract* 7 mm. long, linear, minutely toothed, long ciliate; bracteoles 4 mm. long, otherwise similar to the bracts. *Calyx-tube* 4 mm. long, campanulate, pilose; lobes, 5 mm. long, ovate, acuminate, acute, minutely toothed, pilose. *Vexillum* 1 mm. long, 1 mm. broad, obovate, retuse and with a minute tooth at the apex, shortly clawed, pubescent without; alæ 7 mm. long, 3 mm. broad, oblong, rounded above, with a linear claw 2.5 mm. long; carina 6 mm. long, 4 mm. broad, plano-convex in outline, with a linear claw 3 mm. long. *Larger anthers* 1 mm. long; oblong in outline; smaller anthers .5 mm. long, orbicular in outline. *Ovary* 5 mm. long, 1 mm. broad, linear, villous; style arcuate; stigma capitate. *Fruit* not seen. "Fl. Cap.," ii. 30.

Tulbagh Div.: Sneeuwgat Valley, on the Great Winterhoek, 400 ft., Nov., *Phillips* 1731!; near Tulbagh Waterfall, Sept.-Oct., *Ecklon and Zeyher* 1207!; near Tulbagh, Oct., *Pappe* 12! Paarl Div.: Du Toit's Kloof, *Drège*. Cape Div.: Table Mountain, Nov., *Zeyher*! Also one of two specimens on a sheet *in Herb. Musei. Austro-Afric*!

var. *ciliata*, Phillips var. nov. Leaves never more than 1 cm. long, 7-8 mm. broad, ovate, pungent, longer than the internodes. Flowers appear to be always solitary. *B. ciliata. Willd.* D. C., "Prodr.," ii. 120 *ex parte*.

Tulbagh Div.: Witsenberg, Dec., *Zeyher* 363.

9. *B. MULTIFLORA*. Phillips, sp. nov. (Pl. XXXVI, Fig. A.) *Rami* paullo pilosi vel glabri. *Folia* .8-2.8 cm. longa, .8-2.5 cm. lata, ovata, apice acuta mucronataque, basi amplexicaulis, glabra, margine dentato. *Inflorescentia* terminalia racemosa, plus 5-florifera. *Tubus calyci* 4 mm. longus, campanulatus, villosus; lobi 5 mm. longi, ovati, acuminati, apice acuti. *Corolla* 1.1 cm. longa, villosa. *Antheræ* .75-1 mm. longæ. *Ovarium* 5 mm. longum, compressum, pubescente; stylus arcuatus; stigma capitatum. Fructus 2.2-3 cm. longus, 4.5-5 mm. latus, sub-falcatus, compressus, paullo pilosus. *B. undulata, Thunb., var. multiflora.* **Harv.**, "Fl. Cap.," ii. 30.

Calvinia Div.: Jackalsfontein, *Leipoldt* 944!. Clanwilliam Div.: Brackfontein, Sept., *Zeyher* 1203!. Olifant's River, *Dickson!* Piquetberg Div.: Mountains round Piquetberg, Oct., *Bolus,* 7516!, rocky places on eastern slopes of Pickenier's Pass, Nov., *Pearson in Percy Sladen Memorial Exped.* 5147!. Tulbagh Div.: Porterville Road, *Edwards in Herb. Bolus.*

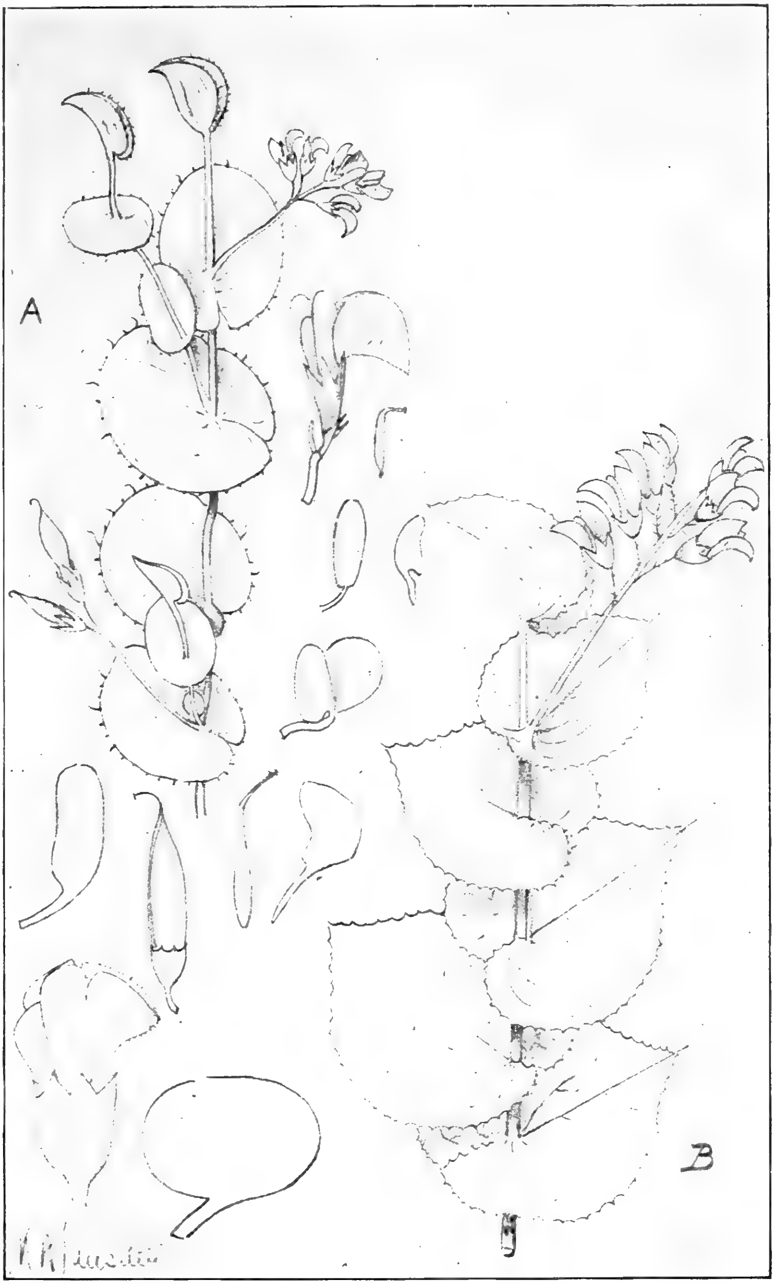
Branches scantily pilose or glabrous. *Leaves* .8-2.8 cm. long, .8-2.5 cm. broad, ovate, acute, mucronate, amplexicaul, at the base, prominently 7-10-nerved, glabrous, with the margin thickened and rigidly toothed. *Inflorescence* terminal, racemose, more than 5-flowered. *Calyx-tube* 4 mm. long, campanulate, villous; lobes 5 mm. long, ovate, acuminate, acute. *Vexillum* 1.1 cm. long, 1 cm. broad, semi-orbicular, villous without, with a channelled claw 4 mm. long; alæ 1.2 cm. long, 3 mm. broad, oblong, rounded above with a linear claw 4 mm. long; carina 1 mm. long, 4 mm. broad, plano-convex in outline, with a linear claw 4.5 mm. long. *Larger anthers* 1 mm. long, oblong in outline; the smaller .75 mm. long. *Ovary* 5 mm. long, compressed, pubescent; style arcuate; stigma capitate. *Fruit* 2.2-3 cm. long, 4.5-5 mm. broad, sub-falcate, compressed scantily pilose.

10. *B. LATIFOLIA* (Benth. in *Lond. Journal*, ii. 462). A shrub 2.3 m. high, erect, with jagged deciduous bark on the older branches. *Stem* terete at the base (*Burchell*); branches sharply angular below each leaf, purple, glabrous. *Leaves* imbricate, concave, sessile, not amplexicaul, ovate-orbicular, acutely and abruptly apiculate, cordate at the base, 2.5-3.5 cm. long and nearly as much broad, rigidly coriaceous, finely cartilaginous-denticulate on the margin, strongly 7-12-nerved on each side, reddish-purple when dry, glabrous, a little reticulate between the nerves. *Flowers* in a dense terminal capitate cluster, only seen in fruit; fruiting pedicels up to 1 cm. long, minutely bracteolate near the middle. *Fruiting calyx-tube* campanulate, about 2 mm. long, glabrous; teeth more or less subulate, as long as the tube. *Pods* all dehisced and spirally twisted, 2-2.5 cm. long, nervose and somewhat viscid.

Caledon Div.: Nieuw Kloof, Houw Hoek Mountains, rocky places, March, *Burchell* 8087.

11. *B. PARVIFLORA* (Lam. Dict. i., p. 437). (Pl. XXXIV, Fig. B.) *Branches* angular, glabrous. *Leaves* .9-3 cm. long, 4-2.6 cm. broad, ovate, acuminate, acute, pungent, cordate at the base, prominently 7-11-nerved above and beneath, glabrous, with scabrid margins. *Flowers* in short dense racemes, terminal and usually partly hidden by the upper leaves. *Calyx-tube* 5 mm. long, campanulate, glabrous; lobes 4 mm. long, ovate-lanceolate, acuminate, acute; the abaxial lobe longer (7 mm.) than the other four. *Vexillum* 1.8 cm. long, obovate, pubescent without; claw 5 mm. long, channelled; alæ 1.8 cm. long, oblong, with a linear claw 5 mm. long; carina 1.8 cm. long, plano-convex in outline, with a linear claw 5 mm. long. *Ovary* 6 mm. long, compressed, glabrous; style 4 mm. long, arcuate; stigma capitate. ***Fruit*** **3 cm. long, 6-5 mm. broad, glabrous. "Fl. Cap.," ii. 29.** ***B. ruscifolia, Bot. Mag., t.*** **2128.**

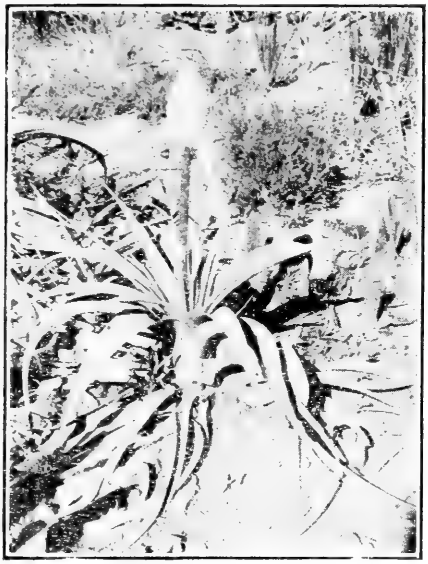
Clanwilliam Div.: Summit Olifant's River Mountains, behind Warmbaths, Sept., *Miss Stephens in Percy Sladen Memorial*



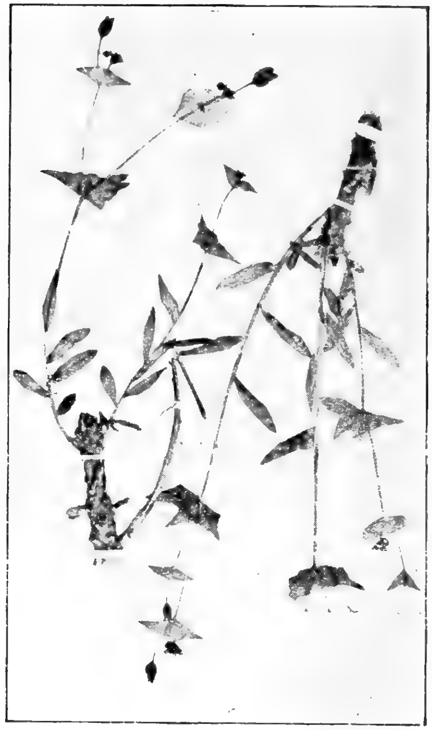
A. *B. perforata*. Thunb.
B. *B. crenata*, Linn.

A. *B. trinervia*, Thunb.
B. *B. barbata*, Lam.

E. P. Phillips—The Genus *Borbonia*, Linn. (Leguminosæ).



(a) *Kniphofia Northiæ*, Bkr.



(b) *Euphorbia Monteiri*, Hook. f.

(c) *Protea rhodantha*, Hook. fil.

E. P. Phillips.—Three Noteworthy Species of Plants from South Africa.

Expedition 7023! Tulbagh Div.: Steendal, Oct., *Pappe* 8!; Winterhoek, *Ecklon and Zeyher*, 1209!. Worcester Div.: Dal Josaphat, 600 ft., Jan., *Tyson* 866!. Caledon Div.: Caledon, *MacOwan*!; mountains round Houw Hoek, c. 1,200 ft., Nov., *Galpin* 3914!; Donker Hoek Mountains, Bavian's Kloof, near Genadendal, Febr., *Burchell* 7818. *Burchell* 7990. Stellenbosch Div.: near Gordon's Bay, c. 800 ft., Dec., *Bolus* 9822!; *Marloth*, 4502b!; Sir Lowry's Pass, 800 ft., Jan., *Schlechter* 7293!, March, *Burchell* 8205. Paarl Div.: Paarlberg, 700 ft., Oct., *Bolus* 2748!; Du Toit's Kloof, *Drège*; near French Hoek Pass, 1,500 ft., Oct., *Phillips* 1099!. Cape Div.: Table Mountain, 250 ft., Oct., *MacOwan in Herb. Norm. Austro-Afric.* 720!; Devil's Peak, Jan., *Wolley Dod*, 587! 725; Table Mountain, Oct., *Ecklon and Zeyher* 1208!. *MacOwan* 2349! 2349b.!, *Bolus*, 2747!, *Burchell*, 36, 468, *Alexander, Sieber* 158, *Thom* 687, *Harvey*, *Pappe*; Lion's Head, Oct., *Zeyher*!; Signal Hill, Nov., *Marloth*, 7237!, 7237b!; Simon's Town, *Wright*; Paardeberg, *Ecklon and Zeyher*!

12. *B. LEIANTHA* Phillips. *Rami* angulati, glabri, *Folia* 1.3-1.5 cm. longa, .5-1 cm. lata, ovata, apice acuta, glabra, margine scabro. *Inflorescentia* terminalia. *Pedicelus* 1.5 mm. longus. *Tubus calyci* 4.5 mm. long, campanulatus; lobi 4.5 mm. longi, ovato-lanceolati, acuminati, apice acuti. *Corolla* 8 mm. longa, glabra. *Ovarium* 4 mm. longum, 1.25 mm. latum, glabrum; stylus 3.5 mm. longus, arcuatus; stigma capitatum.

Caledon Div.: In monte Zwarteberg pone Caledon, Oct., *MacOwan!*

Branches glabrous, angular. *Leaves* 1.3-1.5 cm. long, .5-1 cm. broad, ovate, acute, pungent, cordate or sub-cordate at the base, glabrous, with 6-7 prominent nerves beneath, and with rough margins. *Inflorescence* terminal, umbellate, 3-4-flowered; the flowers somewhat hidden by the upper few leaves. *Pedicels* 1.5 mm. long, glabrous. *Calyx-tube* 4.5 cm. long, more or less campanulate, narrowed at the base, glabrous; lobes 4.5 cm. long, ovate-lanceolate, acuminate, acute. *Vexillum* 8.5 mm. long, obovate, rounded above, glabrous, with a channelled claw 2 mm. long; alæ 6 mm. long, 2 mm. broad, oblong, obtuse, with a linear claw 2.5 mm. long; carina 4 mm. long, 2 mm. broad, more or less plano-convex in outline, obtuse, with a linear claw 3 mm. long. *Larger stamens* 1 mm. long; smaller .5 mm. long. *Ovary* sessile, 4 mm. long, 1.25 mm. broad, ovate-lanceolate in outline, gradually narrowing into the arcuate style, glabrous, stigma capitate. *Fruit* not seen.

This is the only species in the genus with a perfectly glabrous corolla.

13. *B. ALPESTRIS* (Benth. in *Lond. Journ.*, ii. 461). A small shrub with twiggy branchlets. *Branchlets* laxy leafy, not angular, glabrous. *Leaves* ovate, slightly cordate at the base,

with an acuminate pungent point, about 1 cm. long, and 4-5 mm. broad, with about 7 prominent nerves on the lower side, smooth above, glabrous. *Peduncles* 2-3-flowered, about 5 mm. long, glabrous; bracteoles subulate, 4 mm. long. *Flowers* not seen. "*Calyx-tube* 3 mm. long, with narrow setaceous pungent segments as long as the tube" (*Bentham*). *Pod* 2.5 cm. long, 4 mm. broad, acuminate, glabrous.

Robertson Div.: Subalpine bushy places near Kogman's Kloof, 1,000-1,800 ft., Nov., *Mund.*

14. *B. COMPLICATA* (Bent. in *Lond. Journ.*, ii. 462). *Branchlets* rather densely leafy, subterete, glabrous. *Leaves* semiamplexicaul, sessile, rounded-ovate, very sharply spinous, acuminate, cordate at the base, 1.5-2.5 cm. long, thinly coriaceous, rather weakly 8-10-nerved on each side, finely reticulated between the nerves, probably glaucous when fresh, glabrous. *Racemes* several-flowered, terminal, scarcely longer than the subtending leaf, a little curved with the flowers all to one side. *Pedicels* about 3.5 mm. long, very thinly and delicately pilose. *Calyx-tube* 2.5 mm. long, nervose, glabrous; teeth subulate, nearly as long as the tube. *Corolla* not seen in a perfect state. *Young fruits* glabrous, about 1 cm. long.

Piquetberg Div.: Piquetberg, *Drège* (named "*B. parviflora,*" Linn. in Herb. Drège).

15. *B. CORDATA* (Linn. Sp., p. 994). (Pl. XXXVI, Fig. B.) *Branches* villous. Leaves imbricate, 1-2.4 cm. long, .4-1.4 cm. broad, acuminate, acute, pungent, cordate at the base, prominently 10-14-nerved beneath, distinctly nerved above, with the margins smooth and thickened. *Flowers* sub-capitate, partly hidden by the upper leaves. *Calyx-tube* 5 mm. long, campanulate, ribbed, villous; lobes 7 mm. long, ovate, acuminate, acute, pungent, 3-nerved. *Vexillum* 1.5 cm. long, 7 mm. broad above, obovate, densely pubescent without, with a curved channelled claw 5 mm. long; alæ 1.5 cm. long, oblong, pubescent without, with a linear claw 5 mm. long; carina 1.1 cm. long, plano-convex in outline, villous, with a linear claw 5 mm. long. *Larger anthers* 1 mm. long; shorter .5 mm. long. *Ovary* 3 mm. long; style compressed, arcuate; *stigma* capitate. *Fruit* not seen. "Fl. Cap.," ii. 27.

South Africa: Without locality *Pappe, Sieber* 157, *Harvey* 771. Piquetberg Div.: Mountains near Piquetberg, Oct., *Bodkin in Herb. Bolus* 13534!. Malmesbury Div.: Riebeek's Kastell, hills below 1,000 ft., Nov., *Drège.* Tulbagh Div.: Tulbagh Waterfall, Nov., *Zeyher*!. Cape Div.: Table Mountain, Orange Kloof, *Leipoldt in Herb. Bolus* 2747!, *c.* 1,000 ft., Sept., *MacOwan in Herb. Norm. Austro-Afric.* 536!; Jan. *Zeyher* 1210!; above Camps Bay, *c.* 800 ft., Nov., *Galpin* 3915!, *c.* 100 ft., Jan., *Rogers* 3003!; Lion's Head, Jan., *Zeyher*!; Devil's Peak, Dec.,

Pappe!; Kloof over Wynberg Ranges, July, *Wolley* Dod, 1772; Table Mountain and Devil's Peak, *Drège;* Lion's Head, *Alexander;* Table Mountain, *Ecklon* 132; *MacGillivary,* 495; Signal Hill, Nov., *Marloth,* 7236!; Simon's Bay, *Wright*, *Mrs. Jameson;* near Cape Town *Burchell* 37.285. Caledon Div.: near Sir Lowry's Pass, *Burchell* 8281.

IMPERFECTLY KNOWN SPECIES.

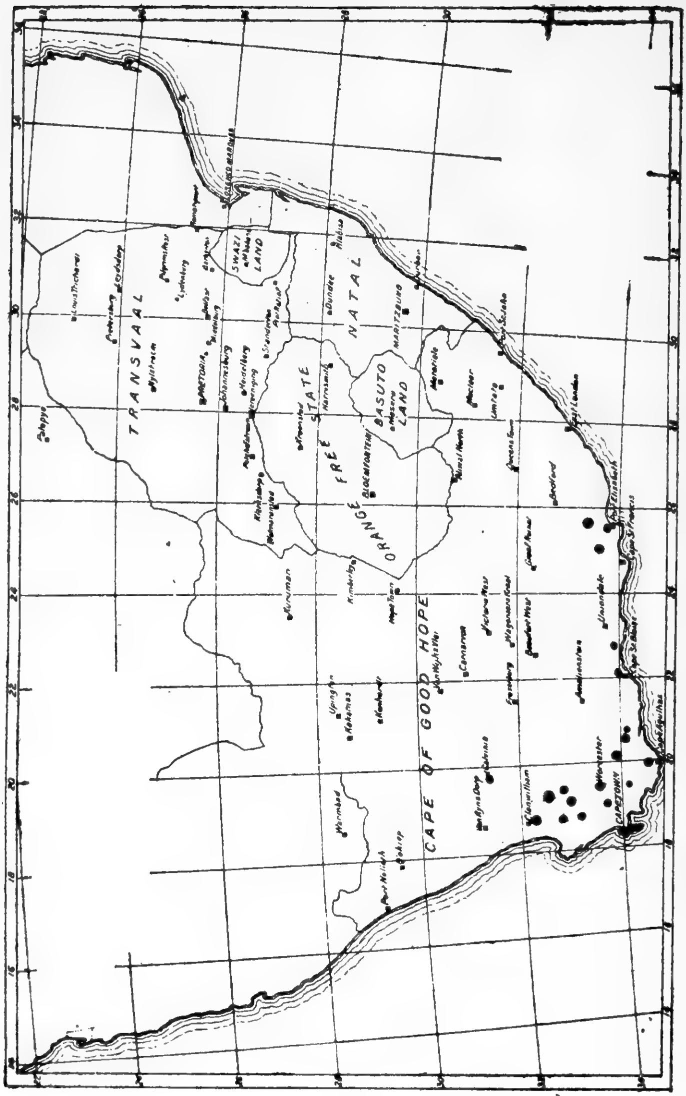
16. *B. ELLIPTICA,* Phillips, *Ramuli,* angulati, glabri. *Folia* 2.4-3.5 cm. longa, 1.6-2.3 cm. lata, elliptica, apice obtusa, 7-9-nervigera, glabra, marginibus scabris. *Fructus* 1.4 cm. longus, 4.5 mm. latus, apice obtusus, glaber.

Mountains near Vogelgat, *c.* 2,000 ft., Dec., *Schlechter* 9547!.

Branchlets sharply angular, glabrous. *Leaves* 2.4-3.5 cm. long, 1.6-2.3 cm. wide, elliptic, obtuse, 7-nerved, glabrous, with scabrid margins. *Fruits* 1.4 cm. long, 4.5 cm. broad, obtuse, glabrous.

Near *B. parviflora* and *B. latifolia,* but differs from both in the leaves not being mucronate at the apex and non-cordate at the base.

The following map shows the distribution of the genus:—



Distribution of *Borbonia*. Localities indicated by round dots.

THE TRAINING OF FITTER-APPRENTICES IN THE WORKSHOPS OF THE PRUSSIAN-HESSIAN STATE RAILWAYS.*

By W. J. Horne, Capt. R.G.A., A.M.I.C.E.,
Organiser, Technical Education, Transvaal.

Read July 10, 1919.

Far-seeing measures were taken in the seventies to deal with the apprenticeship problem in Germany. About 1874 Bismarck, having returned about this time from an exhibition of world industries in America, stated that great improvement was needed in German manufactures; he had found manufactured articles from his country much surpassed in quality by the manufactures of other countries, and particularly of Great Britain. That was practically the beginning in Germany of provision for the organized training of apprentices in trades. Enquiry into existing provisions were forced by the German Government, and early in 1878 an "imperial decree" was issued calling for reports from various industries and works on the question of apprenticeship training. As a result of the reports forwarded by the various railways at that time under the control of various minor German States, the Minister for Commerce, Industries and Public Works[1] issued the following decree:—

"The reports made consequent upon the Decree of February 19th, 1878, have shown me that attempts made up to the present to train young people as mechanics in the big railway workshops have been few, and attended with but a comparatively slight measure of success. It is complained that many of the apprentices leave their work even during the apprenticeship period, and that finally only a small proportion of the trained men remain on in the workshops. It is pointed out that the peculiar conditions in the repair shops are bound to lead to a one-sided and inadequate training for the apprentices; that neither foremen nor charge-hands are in a position to carry out the strict supervision necessary; that, in view of the inexperience of the apprentices and the danger attaching to the work done, the apprentices are exposed to the risk of injury, for which the companies are obliged to take responsibility; that unsupervised companionship with workmen has a bad influence on the morals of the apprentices; and, finally, that in most places there is no need to train apprentices because there is a sufficiency of skilled men available, and that, where this is not the case, the present system might be retained in an improved and extended form, but it will always be a matter of great difficulty to keep the men so trained bound to the shops, since they invariably prefer to go off to other districts, partly in

* Abstracted from a lecture given by B. Schwarze, Doc.Engr., to the Association of German Mechanical Engineers, September 19th, 1916.—An endeavour has been made to give the sense rather than the letter of the lecture, and, therefore, paraphrases have been freely used. The order of certain sections also has been changed, so as to give a better continuity. For Notes see end of paper, p. 424.

the interests of their further training and partly through restlessness. Many railway companies point out that it would be better to have the men they employ in their shops pre-trained in special schools—which, they suggest, might possibly be established later—than to undertake the training of apprentices themselves, a matter, they say, that were far better left to the mechanical trade [guild] and to small factories.

"While most railway companies declare against the acceptance of a large number of apprentices for training, the Royal Railway Commission at Wiesbaden reports on the favourable results of the practice, and states that over 25 per cent. of the men now employed in their shops have been trained in those shops. The success of the practice in the Bergisch-Märkischen Railway is well known.

"The conditions of engagement for apprentices vary; in some, no articles of apprenticeship are signed; compulsory attendance at school is not insisted upon everywhere; the period of apprenticeship is usually three or four years, with a daily rate of pay of 40 to 60 and even 80 pfennigs[2] to start, with an increase annually. Generally speaking, the railway companies do not intend to carry on the training of apprentices except in a few individual places where there is a dearth of skilled workmen.

"I do not approve this view. I regard the training of good mechanics as a task which the railway companies—especially the State railway companies, which employ so large an amount of skilled labour—should feel it their duty to perform. The circumstance that a large number of workmen is at present available cannot be taken into serious account, since many complaints have been made of their inefficiency, and especially with reference to locomotive work. Also, it is clearly the business of the railway companies to help on the intellectual and moral education of the apprentices and to bring it into harmony with their practical training.

"While I am perfectly cognisant of the great difficulties due to the peculiar conditions of the railway workshops, I am nevertheless convinced that these could be overcome by suitable management, especially if the systematic education of mechanic apprentices were regarded as a duty to be performed on general principles, and not merely as a means of supplying the needs of individual shops. The money and trouble spent on this work would ultimately benefit both the workshops and the railway companies themselves.

"It seems clear that even if the trained apprentices leave the workshops in which they have been taught, they will certainly seek employment later on in some other railway workshops, and that they will undoubtedly form a class from which good engine-drivers and railway mechanics may be taken. For these reasons I regard the general training of mechanic-apprentices in the large railway workshops as a fruitful and valuable work to be undertaken in the general interest.

"For the attainment of the uniformity necessary to the conduct of this work, the attached draft[1] of the principles upon which the training of apprentices is to be based has been drawn up. In drawing up the scheme, the view of most of the railway companies has been adopted; namely, that the employment of apprentices in the workshops of the big industrial establishments is not desirable for or advantageous to either the technical or the moral training of these young people. It has therefore been arranged that the actual mechanical instruction of the apprentices should be conducted in special training shops adjacent to the main workshops. These training shops are to be installed [equipped] on similar lines to the main workshops[3] and the apprentices are to be under the constant supervision and guidance of a reliable instructor. The close co-operation with the main workshops will ensure a regular supply of useful work for the training shops.

"The apprentices will not be drafted into the different shops of the main workshops until they are perfectly familiar with the actual execu-

tion of the various mechanical operations. They should then be so far advanced in physical, intellectual and technical development that the before-mentioned circumstances will no longer exert a harmful influence on their further training. A further extension of this system would be the installation of training shops for fitters in all main workshops. The possibility of training carpenters in the main workshops should also be considered.

"The draft[4] appended is submitted to the Royal Railway Commission for detailed examination of the various points, and for suggestions as to any practical modifications. Information is to be sent in, for the purpose of preparing the installation of the training shops, regarding the probable cost of erecting buildings, the purchase of school equipment, and the purchase of machine and other tools as far as these cannot be supplied from stock. Special directions are to be drawn up for instructors and for apprentices; also, a syllabus of the training and a draft of the articles of apprenticeship, taking into account paragraphs 105 to 133 of the Industries Act (Imperial Law of July 17, 1878).[5] These are to be forwarded within six weeks, together with a report on the method by which the preliminary expenses will be covered and the expected increase in current expenses involved by the scheme. As the calculation of wages, material, etc., cannot be specially drawn up, since it is necessarily based on the workshop accounts or upon the work turned out from the training shops,[6] the schedule of future expenditure will be concerned mainly with the expenses of instruction.

"(Sgd.) MAYBACH,
Minister."

"Ministry of Commerce, Industries and Public Works,
Berlin,
December 21st, 1878."

The "decree" is given at length as of interest in indicating the difficulties to be overcome on the question of apprenticeship in the workshops of the State railways and in those of private railways under State control. In many ways it was a question of creating something entirely new, of abandoning the old method of haphazard training in the course of [daily] work and of individual training by masters [employers], by devising a regular plan of training in special training shops. The method is said to have stood the test of many years of practice, has been much copied, and is still used as a model to-day—but much perfected owing to the extension of the apprenticeship system.[7] This decree represents a most important piece of social work [legislation], a fact which the [German] public do not recognise sufficiently clearly. In 1879 training shops were opened at Limburg and at the big Fulda Works, and, in 1887, at Halle. In 1903 a development took place of great importance to the apprenticeship question in the form of a new "decree" regulating apprenticeship afresh. Practically all the principles laid down in 1878 were retained, details being altered to suit changed conditions. These regulations[8] deal with the following points:—

Acceptance of Apprentices.—Number; physical fitness; education; age; other conditions of acceptance. Registration of candidates and order of calling-up; time of starting; articles of apprenticeship; affiliation to Sickness and Pensions Benefit; estimate of pay; savings.

Training.—Period; branches of the mechanic's trade; practical training and its conduct; theoretical instruction; hours of work; scheme of training in the State Railway Workshops.

Examination.—Examination on completion; certificate of training and of examination; failure to pass and repeat examination; examining board; rewards; further employment on completion; transfer regulations; regulations for the examination of mechanics in the main and secondary workshops of the State Railway Company.

The apprentice's training, then, falls into two quite separate sections, *i.e.,* the time spent in the training workshop and the time spent in the main [or commercial] workshop. The chief difference lies in the fact that the first two years[9] are exclusively devoted to the instruction of the apprentice under special masters appointed for this purpose. In the second half [of his training] the apprentice takes part in whatever work[10] is being done, and the training is no longer given by [special] instructors, but by example and occasional demonstration. It is possible to provide special [training] workshops for apprentices at the larger industrial undertakings only, as these entail a considerable amount of expense and trouble for which the work achieved by the apprentice is only a small compensation.[11] On the other hand, a thorough and careful education of the apprentice is possible, such as is not to be obtained in the ordinary workshop; setting aside the fact that they are not always so well suited to the task of instruction as the specially trained teachers, none of the workers —when there is pressing work to be done—can spare the time necessary for instructing [the apprentices]. In allotting work in these workshops, the danger arises of apprentices being given work for which no other workers are available—work which can easily and incidentally be performed [by apprentices]; neither is attention always paid to the fact whether the work thus given is beneficial in the instruction to be gained from it. Thus, the apprentice may be employed in cleaning-off hundreds of castings [off one pattern]; again, large numbers of the same tools may be made in another workshop. Even if the instructor has himself arranged a number of practical exercises, inspection has shown that his choice is seldom an unbiassed one; the apprentices are [thereby] not only *not* trained to become skilled in all branches of the trade, but there is no progressive instruction—from easy to difficult—to interest the apprentice. For example, apprentices have been made to spend from one to two months on filing a cube from a rough forging as a first exercise. In the hands of an unskilful beginner, the object becomes smaller and smaller, and often this same task has to be begun again upon a fresh forging. Then indifference and aversion—the worst enemies to progress—take the place of pleasure and zeal.

The necessity for methodically worked-out [course of] practical exercises for the purpose of enlarging the apprentice's

training has been felt by those larger private [non-governmental] industrial concerns. Thus, the firm of Siemens and Halske make the following statement in their training scheme for their apprentices:—

"By a strictly methodical, from easy to difficult, gradually progressive plan of work, the apprentices are so far advanced after one year that they can immediately proceed to a suitable workshop to be made quite efficient."

Similarly, the apparatus works of the General Electric Company have arranged a course of training for their apprentices' workshop in which the individual carrying-out of practical tests is worked out. From an inspection of their plan of instruction, it is evident that the course is made gradually to increase in difficulty and, above all, instruction in machinery is given special attention.

It is, therefore, recommended that the course of training in the apprentices' workshop should not be left to the choice of the instructor. I have drawn up for the workshops at Guben a series of practical exercises, covering various points [in training]. At the end of each half-year, and only when he has completed these exercises, the apprentice may be allowed to assist with other work. There is, then, a guarantee that he has really been instructed in all the branches of his trade as required by the regulations.

For practical instruction in the third and four years[12] of training, courses in the following departments of the workshops are prescribed:—

(i) Locksmiths' shops;[13] (ii) brazing shop;[14] (iii) brass foundry; (iv) mechanics' shops;[15] (v) at various machine tools; (vi) vehicles; (vii) forge; (viii) locomotive shop.[16]

The eight departments in which it is laid down that the apprentice shall be instructed are not all of equal importance to his future career. For instance, in the brazing shop and the brass foundry, in the turners' shop and at the forge, work is done which a locksmith [for example] later hardly ever has to carry out. It is not, however, advisable to cut short the instruction of the apprentice at this point.[17] In one of the large principal workshops, the apprentices, not long ago, were employed for a month each in the brazing shop and brass foundry, three months in the mechanics' shop, and six months in the carriage shop. This arrangement [of time] is wasteful, and is not without prejudice to the training [of the] apprentice, [especially] as the apprentice is given [on] the same [kind of] work during the whole of the time in the locomotive department [the fourth and last year]. In order that the apprentices may obtain a thorough and regular training, it is advisable that two months only should be spent in the locksmiths' department, one month [each] in the brazing shop and brass foundry, and three months only in the coach-building shop.

As all the apprentices cannot be employed together in any department or section of the workshop at one and the same time, it becomes necessary to distribute them among the various sections. This distribution requires considerable care, as it is necessary to ensure that each apprentice goes through every section as prescribed, that the prescribed time is adhered to in each, and that the number of apprentices that can be accommodated at one time in any section is not exceeded. This is best done by preparing beforehand a tabular scheme showing the order in which the apprentices, or groups of apprentices, enter the various sections of the workshops. Such a table appears on the opposite page.

The distribution table or schedule just described is used to indicate to the apprentices the progress they are making. Copies of the form are posted on notice boards in each shop, the columns, in the first instance, being kept blank; the key letters for the various sections of the training are entered against each apprentice or apprentice-group as he (or they) enter the section laid down as next in order. In all departments, or sections, of the main workshops the apprentice is still considered as belonging to the "training workshop," and, consequently, the apprentice's progress is supervised by the chief-instructor of the "training workshop," as is required by the Regulations, who promotes him accordingly to the next section in order of training. The apprentices are under the control of the chief instructor in every respect, even as regards behaviour out of work hours, until the period of apprenticeship [four years] has been completed. The regular instruction under continual supervision and strict discipline produces very excellent results that have been repeatedly praised by recognised experts. The change from one section to the next takes place on the first of each month [in the cases of those promoted]. It has still to be proven whether it is desirable to place apprentices in a particular group [once and for all] or to put them singly into existing groups [on promotion to the next section]. Opinion on this point is divided.

Every apprentice carries on his person a report-form, which must be produced on demand. The apprentices attend with their forms before the Board of Directors at the end of each period [half-yearly] of instruction; the apprentices are questioned by the Directors, and from the manner of replying and general bearing, together with the portion of the report dealing with diligence, progress, and behaviour, provided by the work-master, and the remarks and notes of the chief-instructor and the works manager or engineer, [the Directors], taking into account whether the latter is or was employed by the Railway Company, are able to arrive at the relationship [suitability] between the apprentice and the Railway Administration. The cases of apprentices who appear to be badly developed or ill may be gone into. The result of the apprentice's examination [in his trade, "proefwerk"] is confirmed by [endorsed on] the form.

DISTRIBUTION OF APPRENTICES TO DEPARTMENTS.

No	Letter of Group. [Or Names of Applicants.]	THIRD YEAR. 1910												FOURTH YEAR. 1911								1912			
		May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
1	A	bc	l	e	e	d	d	d	f	f	g	g	g	o	o	o	o	o	o	n	m	a	h	i	k
2	B	a	bc	f	f	d	d	d	e	e	g	g	g	l	m	n	h	i	k	o	o	o	o	o	o
3	C	f	f	bc	a	d	d	d	g	g	g	e	e	m	n	l	i	k	h	o	o	o	o	o	o
4	D	f	f	a	bc	g	g	g	d	d	d	e	e	k	h	i	l	m	n	o	o	o	o	o	o
5	E	g	g	g	e	e	f	f	d	d	d	bc	a	o	o	o	o	o	o	h	i	k	l	m	n
6	F	g	g	g	e	e	bc	m	n	l	a	f	f	d	d	d	k	h	i	o	o	o	o	o	o
7	G	g	g	g	f	f	a	bc	e	e	m	n	l	o	o	o	o	o	o	i	k	h	d	d	d
8	H	h	i	k	f	f	g	g	g	n	bc	l	m	d	d	d	e	e	a	o	o	o	o	o	o
9	J	i	k	h	g	g	g	a	d	d	d	f	f	o	o	o	o	o	o	bc	l	m	n	e	e

KEY.

Tool Making = a = 1 month.	Forge = f = 2 months.	Bolt Making = k = 1 mth. (20)
Coppersmithing = b = } 1 do.	Coach Building = g = 3 do.	Armature Work = l = 1 do. (21)
Brass Foundry = c = } 1 do.	Gunsmith's Work = h = 1mth. (18)	Ventilators = m = 1 do. (22)
Mechanics' Shop d = 3 months.	Piston Fitting = i = 1 do. (19)	Boiler-tube Fitting = n = 1 do.
Locksmith's Work = e = 2 do.		Locomotive erecting = o = 6 months.

[Making a total of 24 months.]

These practical examples must suffice to give an idea of the nature of the proceedings conducted, and to show the value which is attributed to carefully organised instruction in the leading industrial centres [of the Railway Administration and other firms quoted].

In an examination of the number of apprentices [taken on] relative to the number of paid employees, it should be noted that the extension of the railway system has not always affected the number of apprentices proportionally. Particularly, the taking over by the State of so many important railway companies in 1880-1885 did not raise the number of apprentices to a corresponding extent. Possibly the reason was that the different private companies had not all made identical arrangements for the training of the new generation of mechanics. As soon as these companies were absorbed in other State railways, the railway system and the number of apprentices began to grow in approximately the same ratio. Of course, the number of apprentices depends upon the number of fitters and turners employed, and not upon the number of paid employees. Hence we find that the Regulations limit the number of apprentices to the measure set by the permanent [actual] requirements of the State Railways, and that this number may not exceed in [any] one management district twelve and a half per cent. of the number of fitters and turners employed in the main and auxiliary workshops [of that district]; the number of apprentices distributed to each workshop in a district is then settled by the Railway Administration, but this must not be less than five yearly in any one workshop by the Apprenticeship Regulations. That is to say, the number of apprentices for each district is first ascertained in accordance with the number of fitters and turners employed in the district, and these are then distributed to the individual workshops in that district, care being taken that the number does not drop below the minimum of five apprentices per annum per workshop. In 1914 there existed 65 special "training workshops" for apprentices [dealing with the first two years of apprenticeship] and two auxiliary shops where the same training was given; these special workshops were distributed over 21 districts, two (Berlin and Frankfort) having five, and the others four, three, and two shops each according to the size of the main workshops and the importance of the district from railway considerations. The total number of apprentices undergoing training at June, 1914, in these special shops was 3,544, the smallest number in one shop being 15, and the highest 117 apprentices; 22 shops had from 20 to 40, and 26 from 40 to 60 apprentices under training.

At June, 1914, the number of apprentices in these shops averaged 5.1 per cent. of the number of the mechanics and unskilled workmen employed in all railway workshops; the minimum being 1.9 per cent., and the maximum 7.3 per cent.

Data on the subdivision of the paid employees according to trades is available for the year 1913 only, when fitters and turners formed 41 per cent., other mechanics 20 per cent., and unskilled workmen 39 per cent. of the total employed men. Assuming that this proportion holds, more or less, the percentage of fitter-apprentices to journeymen fitters and turners does not differ much from 12.5 during the financial year 1914-15. During the war this percentage went up, however, to 15 and over. A study of the growth in the number of workshop employees from 1879 to 1914 shows that the increase in the number of apprentices has not kept step; that is, the number of apprentices is insufficient to supply the demand that is likely to arise for journeymen. The fixing of a higher rate than 12.5 per cent. is, therefore, not only justifiable, it is necessary. This is confirmed by the experience of the main workshops at Guben; a yearly average of 640 workmen were employed before the War, of whom 240 were fitters and 25 turners. In normal times about 40 vacancies for fitters and two for turners had to be filled annually owing to deaths, retirement, pensioning, becoming officials or taking employment with private firms. Of these 42 vacancies, generally not more than 9—*i.e.*, 22 per cent., or scarcely more than one-fifth—could be filled from the apprentice ranks; the management had to turn to outside industries for the remaining 78 per cent. Even this 22 per cent. were not permanent; only 80 per cent. of the apprentices remain in the railway service, and of these many become railway officials. Thirty-four per cent. only remain permanently with the railway as mechanics. So that [as far as Guben is concerned] only 7 of every 100 vacancies for fitters and turners are permanently filled by former apprentices; now this is the position in a main workshop which trains apprentices; in other main and auxiliary workshops which do not do so [of which there are 22] it is a mere chance if all the vacancies have not to be filled from sources outside the railway workshops. This is disquieting; good mechanics are generally better paid at the start in private works than in the railway shops, particularly in the West. There is, therefore, the danger that the less efficient men who do not get on in the works of private firms will drift to the railway shops, where they will have to be accepted owing to the scarcity of labour. This high percentage of extraneous and indifferent labour will tend to lower the output of the whole works.

The number of apprentices [taken] could be very considerably increased, the more so that the supply of [would-be] apprentices is extraordinarily large compared with the [number] of mechanics [offering]. It would be bigger still were it not for the fact that the sons of non-railway workers are not, as a rule, accepted. Most of these [external] applicants do not make written application after verbal information of the lack of prospects [*i.e.*, of this rule]. At Guben no written application was

received from a non-railway source in the ten years from 1905 to 1914. During that period nine apprentices were taken on annually; the number of applicants in the neighbourhood has varied irregularly from 12 to 25 for the nine vacancies. In addition to the economic condition of the local industry and of the trade [generally], there is certainly some element of chance in the number of applications for apprenticeship in the State Railways.

After the War there will be a great shortage of good mechanics for several years, and private firms will endeavour to secure the best men by offering high wages. In expectation of this scarcity, several important Associations, such as the Society of German Engineers and the Association of German Engineering Works, have turned their attention to the thorough and careful training of young blood. In 1911, Dr. B. A. Rieppel, Government Inspector, Nüremberg, moved the following resolution as a member of the Labour Committee for Lower Technical Schools:[23]

> "The engineering trade must maintain a staff of apprentices and provide a four years' training [to the extent of]—
>
> "(*a*) Fitters and Turners, each 20 per cent. of the mechanics employed; and
>
> "(*b*) Moulders, Pourers and Smiths, each 12 per cent. to 14 per cent."

The Labour Committee, however, put forward that,

> "Assuming a 3 to 4-years' training, and taking the average working life of a trained mechanic as 30 years, 10 to 12½ apprentices for every 100 mechanics would appear to be sufficient to meet the requirements of any works."

In the choice of candidates for a vacancy the business man or works manager chooses the best; it would be an advantage if the same condition[24] could be fulfilled when selecting railway apprentices; but, unfortunately, this is not always possible. In taking on apprentices, actually the future traffic and workshop superintendents are enrolled, which is sufficient reason for extreme care. Also, there is the danger of a boy being pushed into the trade of fitter by his family contrary to his inclinations or to his suitability, simply because there is an opening which can be secured fairly easily on the score of necessity. Workmen have themselves pointed out that this danger really exists. Engaging a boy as a railway apprentice eases the condition of his family and [thus] assumes unintentionally the nature of economic relief. As a rule the number of applicants claiming special consideration on the ground of poverty is large, and double the number of vacancies often would not suffice. The usual reasons are urged—large families, death of one or both parents, etc. In the case of the son of a widow with numerous children, the father having been killed in the employ of the railway as a shunter, for example, it must be admitted that it is

in accordance with economy and the dictates of kindly feeling to give such a boy preferential treatment even though there may be more suitable candidates. But however much such personal feeling should weigh, there is serious danger in allowing it to have too much influence; for example, the most suitable candidates might be prevented from becoming railway apprentices unless they happened to be members of large or fatherless families. Apart from this injustice, the standard of apprentices might very well fall below the average.

There are several points in the Statutory Regulations for Apprenticeship which might be modified to provide a better choice. These do not contain any statutory instructions on previous school knowledge, so that private works are not restricted in the qualifications of the boys they accept as apprentices. From the railway point of view it is unfortunate that any applicant who has been turned down as an apprentice on account of insufficient schooling can be taken on in later years as a workman, and is then in the same position as regards pay and occupation [status] as the former State apprentice who has had to exert himself much harder at school. Nothing is stated directly, either in the Industries Act or elsewhere, about a minimum age; this is given indirectly, however, by the school-leaving age, which is about 14 years: there is no upper limit to the age, and instructors are free to accept older apprentices, which is sometimes done; boys below 14 years may not be employed for more than six hours a day. The Amalgamated Union of German Metal Workers have drawn up "Notes on the Indenture of Apprenticeship in the Engineering and Metal Trade," two points from which might be included with advantage in the State Railway indenture; these are (i) empowering the employer to extend the period of training agreed upon over a number of days corresponding to the days lost by the apprentice through illness, accident, etc.; and (ii) power to transfer the educational rights of the employer to the person actually entrusted with the training of the apprentice—this last because, for example, if even slight corporal punishment of a refractory boy were necessary, this can only be inflicted personally by the Board [of Directors].

LIST OF PRACTICAL EXERCISES AT THE TRAINING WORKSHOPS FOR APPRENTICES OF THE STATE RAILWAYS AT GUBEN.

First Half-Year.

A.—Filing.

1. Filing two rectangular pieces each 100 × 50 × 20 mm.
2. Filing an end of exercise 1 to an angle of 45°.
3. Filing a groove containing an angle of 120° in the other end of exercise 1, and filing V and fitting to it a V-end on another piece.
4. Filing a rivetting hammer.
5. Filing and fitting a pair of pincers (ordinary pattern).

6. Filing and threading two nuts of different sizes for cross-head bolts and eccentric-rods.
7. Filing, assembling and rivetting the parts of a sliding-bolt (fastening) for a tool-box on loco. foot-plate.
8. Ditto, more intricate pattern, including cold-bending.
9. Making a key-stock and two bits; fitting the bits to a diminishing or swallow-tail groove in the stock.
10. Filing screw-thread for wood on round-bar iron and bending it to form a coat-hook.
11. Filing a double-headed spanner from solid stuff.
12. Filing a cube.
13. Filing cold chisels, flat and cross-cut, a screw-driver blade and a centre-punch.

B.—Grinding and Emery Polishing.

1. Polishing and grinding the bevels on the pieces of exercise A, 3.
2. Polishing a water-gauge cock.
3. Scraping and fitting a pair of journal brasses.
4. Making and finishing a ½-metre straight-edge.

C.—Cutting, Chipping and Sheet-Metal Work.

1. Practice on angle and channel iron.
2. Cleaning-off castings.
3. Cutting-out and making a pair of butt-hinges.
4. Cutting-out and making protecting aprons and corners for goods wagons.
5. Cutting-out and making a sheet-metal pail.

D.—Soldering.

1. Hard-soldering the bits to stock of exercise A, 9.
2. Making a cylindrical iron pot for reddle on large circular base and hard-soldering the seams or otherwise as required.
3. Making-up and soft-soldering a tin-plate soap-box.
4. Making-up and soft-soldering a tin-plate paint-can.

E.—Completing Simple Articles.

1. Making a simple cupboard lock with key.
2. Making a simple padlock and key.

F.—Assisting with simple Repair Work [in the Main Shop].

SECOND HALF-YEAR.

A.—Angles, Clips, etc.

1. Clips for brake pipes (circular bending).
2. Window-corner angles (edge bending).
3. Window finger-lifts.

B.—Drilling.

1. Drill and counter-sink holes for single and double-rivetted lap joint.

C.—Cold Rivetting (up to 8 mm. diameter).

1. Single- and double-rivetted lap joint.
2. Rivetting a sheet-iron bucket from exercise 1, C 5.
3. Rivetting aprons or ends for sand-blast pipe.

D.—Threading Iron and Brass with Stock and Dies.

1. Plates of exercise 1, A 3, to be drilled and tapped $\frac{1}{16}''$, $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{1}{2}''$, $\frac{5}{8}''$, $\frac{3}{4}''$, $\frac{7}{8}''$, and 1″.
2. Make three screwed plugs from round iron in three sizes (diameters), each having square head for box-key.
3. Drill and tap brass-plate to $\frac{1}{16}''$ and $\frac{7}{8}''$.
4. Thread a ½-metre length of 6 mm. brass wire as reinforcing tie for red brasses.
5. Gas-thread iron tube and fit sockets, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, and 1″.

E.—Marking-out, Shaping, Fitting and Completing.

1. Dividers (6″ to 8″).
2. Spring mortise lock (door).

F.—Polishing.

Polishing and grinding parts as required (keys, etc.).

G.—Assisting in simple repair work [in main shop].

Third Half-Year.

A. Smithing Iron and Steel.

1. Stretching and bending flat iron up to 15 × 50 mm. cross-section.
2. Upsetting and drawing-down round iron of 30 mm. diameter.
3. Welding in flat and round stuff (simple).
4. Forging and finishing a box-key (square socket).
5. Forging a rivetting hammer.
6. Forging a pair of pincers, a pair of pliers.
7. Shortening and re-welding at cut a brake rod.

B.—Steel Tools, Hardening, etc.

1. A flat chisel, cross-cut, centre-punch and screw-driver.

C.—Assisting generally in repair work [in main shop].

Fourth Half-Year.

A.—Wood-turning.

1. Cylindrical rod or bar.
2. File handle (with ferrule).
3. Cock-handle (hardwood, bored).
4. Hand-wheel for eight-feed lubricator, recessed and bored.

B.—Metal Turning.

1. Cylindrical ruler.
2. A flat circle.
3. Buffer bushes (collars).
4. Spring washers.
5. Pins or bolts for screw-couplings.
6. Conical pipe-plugs.
7. Brake handles, etc.
8. Tooth-catch plate (circular) fixing reversing gear spindle in adjustment.

C.—Screw Cutting (Lathe).

1. Threading the rod of exercise 4, B 1.
2. Screwing bolts, $\frac{1}{4}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $\frac{7}{8}''$ and 1″. } Machined.
3. Nuts for bolts as above. }
4. Cutting threads in given rough nuts (no machine finish).
5. Square thread $\frac{1}{4}''$ pitch on a spindle.

D.—Planing.

1. Cast-iron liners and distance pieces.
2. Square and hexagon ends to round bar.
3. Sliding pieces for buffers and spring spindle washers.
4. Vee-guide and slide planed from flat bar, 60 × 20 mm.

E.—Forging, Finishing and Assembling.

1. Monkey wrench.
2. Ratchet drill (brace).
3. Hand-vice.
4. Turning and planing tools, and cutters.
5. Number punches.
6. Letter punches.

F.—Hot Rivetting.

1. Single rivet simple lap-joint, cupped rivets.
2. Single rivet simple lap-joint, countersunk (flush) rivets.
3. Simple butt-joint and strap.
4. Rivetting gussets to diagonal members of wagon under-framing.
5. Rivetting angle frames.
6. Rivetting door framing for an iron, 15-ton, coal truck.

G.—Completing Difficult Articles Requiring High Finish and Taste.

1. Making a screw stock and dies.
2. Making an artistic lock, grille, etc.

H.—Assisting in difficult and heavy repairs [in main shop].

NOTES REFERRED TO IN THE TEXT.

[1] Technical education for all trades and industries, including commerce, is under the direct control in Germany of this Ministry.

[2] A mark=100 pfennigs, was equivalent approximately to 9½d. about that time.

[3] A similar system is in operation at the Pietermaritzburg Shops of the S.A.R.

[4] The draft referred to contained sixteen sections dealing, among other matters, with:—

Number of apprentices—"generally not more than 8 to 10 a year in a large workshop."

The articles of apprenticeship to be signed by the contracting parties: A probation of 8 weeks is provided for; the working hours are ten, and the pay not to exceed 80 pfennigs a day. The instructor is a charge-hand, who may be promoted to foreman; he is directly under the head of the department, who has supreme control over the "training shop" under the general direction of the works manager.

The main principles are given upon which is to be based the scheme of instruction for mechanic-apprentices in the workshops of the State Railways, and of private railways under State control.

[5] There is some legal doubt whether the Industries Law can be applied to railway companies or not; opinions differ. The Minister has the power to give an order by decree, which he does here.

[6] The scheme of practical work given at the end scarcely justifies the commercial value of the work expected, apparently, by the Minister.

[7] The extension referred to is that due to the "Manual Workers' Order," issued under the Industries Act.

[8] "Lehrlings-Verschriften in Eisenbahn Verordnungs," Blatt No. 2, Jan. 19, 1903. From all P.O.'s and booksellers. Price 1 mark.

[9] Spent in the "training workshops."

[10] *I.e.*, in the main or commercial workshop.

[11] This would appear to justify the establishment of trades schools as distinct collective institutions, as in Holland (since 1857), and as adopted for Bavaria and South Germany generally by Kerschensteiner. Such separate institutions are now common in Germany, Sweden, and other countries.

[12] The apprentices, now being no longer in the training workshops, but in the main or commercial productive shops of the Railway Workshops.

[13] In the German "locksmiths' shop" much of the less exact fitting is done, and metal-plate work of the cold—or snap—rivetted sort.

[14] The "brazing shop" does tin- and copper-smithing, ordinary and autogenous soldering (oxy-acetylene welding).

[15] As in Britain, *i.e.*, engineering fitting proper.

[16] *I.e.*, erecting and repairs shop.

[17] All apprentices, no matter the branch of the metal working at which they are aiming, or in which they finally become journeymen, go through the same course. As a rule, however, the apprentice who fails to get through any one of the shops, in the order given, goes back, and probably qualifies finally in one preceding.

[18] The finer fitting required in gunsmithing is in advance of the rougher fitting learned in "locksmiths' work"; it provides a training in exactitude that will be applied later in the heavy fitting in the mechanics' shop. Certain of the railway (operating) personnel in Germany go armed.

[19] Includes valve-setting and valve-gear adjustment.

[20] For cylinder covers, etc.

[21] The mechanical part: *i.e.*, shaft, spider, commutator, assembling, etc.

[22] Includes, besides the ventilation of coaches, natural and forced draught in furnace and smoke-box.

[23] There are three grades of technical schools in Germany (in addition to trade schools), lower, intermediate, and higher. The German Committee for Technical Schools (all) was formed at the instance of the Society of German Engineers. In 1907 the Minister of Commerce and Industries lengthened the period of training given in the Higher Technical Engineering Schools from four to five half-yearly terms. In 1910 the Society of German Engineers made suggestions concerning Intermediate Technical Schools "of the Metal Trades," and in 1912, concerning the Lower Technical Schools. It should be noted that there are both technical schools (techniese Schulen) *and* trade schools (Fachschulen).

[24] Latterly special tests for intelligence have been set to narrow the selection; these consist of questions, exercises, drawings, etc., upon a scientific basis [psychological, *cf.* Binet's formula]. The Saxon State Railway recently set up a laboratory for testing suitability for employment [in this way].

SESUTO ETYMOLOGIES: PART III.

By Rev. W. A. Norton, B.A., B.Litt.

(*Title only.*)

COMPLETION TESTS FOR SCHOOL USE.

By S. G. Rich, M.A., B.Sc.

(*Title only.*)

HOW PUPILS ACTUALLY REMEMBER SPELLING.

By S. G. Rich, M.A., B.Sc.

(*Title only.*)

CENTRAL AFRICAN FOLK-LORE TALES.

By Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.

(*Title only.*)

ON A ZOOLOGICAL SURVEY FROM AN ENTOMOLOGICAL POINT OF VIEW.

By A. J. T. Janse, F.E.S.

(*Abstract.*)

Read July 9, 1919.

Last year (1918) I tried to point out how rich the insect fauna of South Africa is, how much work still remains to be done, and how fast the flora, and with that the insect fauna, is changing in our country owing to the ever-advancing agriculture. This was done in order to convince you of the necessity of having an organised zoological survey for South Africa, supported by the Government and assisted by all students of zoology in South Africa.

In this paper I try to deal with the question from an entomological point of view, though in some people's view the study of insects is not quite as important as that of other classes of animals. Entomological studies are often looked upon as scientific luxuries, hardly necessities, unless, indeed, it is in solving questions of economic importance. Still, I maintain that it is hardly possible to draw a line of distinct demarcation anywhere in science, and least of all in entomology. How important this group is may be realised by the fact that not less than half the existing animals are insects.

I, therefore, hold that in a proposed zoological survey the study of insects should stand foremost from an economic and scientific point of view.

Such a survey would probably in the first place constitute a proper collecting of material, and here more has to be done than in any other group of animals. It is comparatively difficult to find new species in most other groups, but in practically any order of insects the number of unknown species is probably as large as those that have been described.

Examples from an order with which I am best acquainted may illustrate this. Of the South African Heterocera (moths) 4,025 species have been described up to now, 2,400 named species of which are now in my collection, but not less than about 2,000 unnamed species are in that collection as well, and fresh species are discovered about every week. (Nearly 900 of these unnamed species were shown at the meeting, only 20 of which, as was proved later, were represented in the South African Museum.)

How little is known and how much is still to be done may be seen from facts based also on my own collection, which I tabulate here below.

Genus or Sub-family.	Number of Species described from South Africa.	Number of Named Species in my Collection.	Number of Unnamed Species in my Collection.
Crambus	11	8	42
Scirpophaga ..	1	1	10
Endotrichinæ ..	1	1	19
Acronyctinæ ..	172	91	over 160
Hadeninæ	45	32	38
Erastrianæ	179	108	118
Nolinæ	12	4	44
Lithosianæ	61	36	65
Arctiadæ	55	37	9
Thyrididæ	15	6	21

The above-mentioned examples are not isolated cases; I could have given many more, some even more striking, but the large amount of unassorted material on hand prevented me from giving these. However, I think it shows sufficiently:—

(*a*) How much new material there is to be discovered if all this can be accumulated by one private worker in a period of about ten years.

(*b*) How much material would escape our attention if no systematic survey is made for it.

If we come to the study of the insects, far less is done than in the pure collecting line. Probably less than 1 per cent. of the life histories are known of our insects, a vital point in determining their economic importance. Not a single order of South African insects has been monographed yet, and the few families that have been monographed, such as those of beetles and butterflies, can be counted on the fingers of one hand.

The reason of all this, I think, is—

(*a*) Insufficient material on hand.

(*b*) Insufficient number of entomologists.

To secure the first, such a zoological survey might map out the country faunistically, and one or more of the existing institutions, such as museums, might be made responsible for the exploration of such a region.

Regular expeditions might be arranged to explore *systematically*, each department of research being attended to by the *proper specialist*. Such a combination of specialists would be more economic financially and more beneficial scientifically than the present system, where one or two men go out and have to cope one day with fishes, next with reptiles or birds, and in their spare time catch beetles, gnats, or moths.

Such expeditions might be combined, however, with botanical and geological surveys, provided each had their proper specialists.

Co-operation and division of labour must be arranged among the different existing institutions. Each museum, for instance, instead of trying to accumulate as much material as possible of all classes, could confine its special attention to one or more groups, and have in such a case all the available *unique* material belonging to such a group or groups, which are now spread over the whole of South Africa. I refer now, of course, not to show collections, but to study collections. How much energy would thus be saved and overlapping avoided only a systematist can fully realise and appreciate, and it is surprising that such a thing has not been brought about before.

We lack a sufficient number of workers, and therefore should stimulate and organise the assistance of private workers. How this could be done can be discussed later on.

The zoological survey should give facilities to institutions and recognised workers to prepare monographs of the various groups, such as some countries already possess.

Connection might be established with other Governments to secure assistance in identification, material and books, which are not at present available in South Africa.

I am sure that I have by no means exhausted the subject, but hope to have shown, firstly, how necessary a zoological survey of this country is, and secondly, in what direction its activities may lie.

THE MORPHOLOGY OF THE FLOWERS OF *SALIX*.

By Prof. C. E. Moss, M.A., D.Sc., F.L.S., F.R.G.S.

(*Title only.*)

VEGETABLE RAW PRODUCTS WHICH COULD BE PRODUCED ON A LARGE SCALE IN THE EASTERN DISTRICTS OF THE CAPE PROVINCE.

By Prof. S. Schönland, M.A., Ph.D., F.L.S.

(*Title only.*)

THE ECOLOGY OF THE MELSETTER DISTRICT.

By C. F. M. Swynnerton, F.L.S., F.E.S., F.R.H.S.

(*Title only.*)

THREE NOTEWORTHY SPECIES OF PLANTS FROM SOUTH AFRICA.

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Division of Botany, Pretoria.

With Plate XXXIX.

Read July 11, 1920.

PROTEA RHODANTHA, Hook. fil. *Branches* brownish, prominently pitted with old leaf scars. *Leaves* 16-20 cm. long, 1.2-1.5 cm. broad in the widest part, obtuse, long attenuated at the base, glabrous, the mid-rib distinct in fresh leaves and lateral veins not evident, but are distinct in dried leaves. *Heads* terminal, 9 cm. long from the base to apex of styles, about 7.5 cm. across. *Receptacle* 1.5 cm. high, conical. *Involucral-bracts* 7-8-seriate; the outer 1.5 cm. broad, ovate, bluntly and shortly acuminate, obtuse, glabrous or pubescent on the lower half, ciliate; the inner 3.5 cm. long, 1 cm. broad, oblong, obtuse, glabrous, not ciliate. *Perianth* 6 mm. long, 8 mm. broad at the base, expanded and keeled, glabrous at the base, otherwise villous; the upper portion of the perianth 2.5 mm. broad, linear, villous without and within; lip 2.5 cm. long, 2.5 mm. broad, 3-toothed at the apex, villous. *Anthers* 1.5 cm. long, linear with a linear-elliptic apical gland .5 mm. long. *Ovary* 3.5 mm. long, covered with pinkish hairs; style 5.5 cm. long, gradually tapering upwards from a thickened base, glabrous; stigma 1.1 cm. long, filiform, obtuse, gradually passing into the style.

Barberton Div.: Near Barberton, June, *Thorncroft in National Herb.* 1053. A rare and handsome species of the genus. The involucral-bracts are a deep port wine colour and the long projecting styles are pink. The perianth is also tinged with pink and not with an orange-coloured lip as stated in the "Flora Capensis."

This *Protea* was first raised from seed sent by Mr. Horn, who collected it at Pilgrim's Rest, in the Lydenburg district, in 1886, and it flowered a few years afterwards at Kew. It was described and figured by Hooker in the *Botanical Magazine*, t. 7331. For many years the plant was only known from the figure until Bolus collected specimens in Swaziland, between Dalriach and Forbes Reef (*Bolus* 12265). The specimens sent in by Mr. Thorncroft are the first to be collected since Bolus' gathering, and the locality from which they come is a new record for the species.

KNIPHOFIA NORTHIÆ, Bkr. Plant with a short stem and a dense rosette of leaves 30-40 in number, increasing in size

outwards. *Leaves* up to 1.5 m. long, 7 cm. broad low down, gradually narrowing upwards to a long acuminate tip, glabrous, with the margins densely serrately-toothed. *Peduncle* shorter than the leaves, 1.3 cm. in diameter with 3-4 bracts on the lower half, and many membranous ovate-lanceolate bracts on the upper half. *Inflorescence* dense, about 17 cm. long, and 7 cm. in diameter. *Flowers* all pendulous; the upper reddish; the lower yellowish. *Perianth-tube* in young flowers 2 cm. long, lengthening in older flowers to 3 cm., more or less clavate, distinctly 6-nerved, glabrous; lobes 3-3.5 mm. long, 2.5 mm. broad, ovate, obtuse, with smooth or serrated margins. *Stamens* of two different lengths; in young flowers near the apex the stamens are included; longer filaments 2.5-5 mm. long, cylindrical, glabrous; the shorter filaments 1-3 mm. long, similar to the longer; in older flowers the longer stamens exserted 3.5 cm. long, linear; the shorter included, 2 cm. long, linear. *Ovary* 3.5 mm. long, 2 mm. broad, ovate in outline, glabrous; style 3 cm. long, linear, glabrous; in younger flowers style only 9 mm. long; stigma simple. *Fruit* 9 mm. long, 7 mm. in diameter, subglobose; valves black, coriaceous, glabrous. *Seeds* black, pyramidal in shape, 3-4 angled.

East Griqualand: Kokstad, *Mogg* 1843, and in *National Herb.* 1051. Flowered in Garden of Division of Botany, Pretoria, Oct., 1918. *Garden No.* 5149.

Cape Province: Barkly East Div.: Swampy ground, Ben McDhui, 8,500-9,600 ft., March, *Galpin* 6866.

This handsome *Kniphofia* was first described by Baker in the *Journal of Botany* in 1889 from a painting in the North Gallery at Kew, and from a specimen taken to England by Miss North in 1883, and which flowered in the Succulent House in 1889. The species also flowered at Kew in June, 1894, and was figured in the *Botanical Magazine,* t. 7412, from the living plants. The plant is reported to occur in a wild state in the neighbourhood of Grahamstown, and was first found by Mr. W. Dugmore. Mr. Galpin (No. 5149) was the first to rediscover the species in 1904, and Mr. Mogg collected living specimens near Kokstad in 1917, which he sent to the Division of Botany at Pretoria, where they flowered the following year.

EUPHORBIA MONTEIRA, Hook. fil. *Stems* branched, succulent, rough, about 1.5 cm. in diameter with slender leafy herbaceous branches arising from near the apices. *Branches* 17-28 cm. long, simple or branched, 1.5-3 mm. in diameter, green, glabrous; each branch bears at its apex an opposite pair of bracts which surround a peduncled involucre and a shoot. *Leaves* sessile, alternate, 3.3-4.1 cm. long, rarely as small as 1.2 cm. long, .8-1 cm. broad, lanceolate, very shortly acuminate and acute at the apex, slightly narrowed at the base, glabrous, with the mid-rib evident and with entire margins. *Bracts 2,* opposite, 1.8-3 cm. long, about 2.4 cm. broad at the widest part,

ovate, shortly acuminate, acute, glabrous. *Involucre* peduncled, 6-8 mm. in diameter, more or less campanulate, glabrous, with 5 glands and 5 more or less quadrate lobes, fimbriated at their truncate apices. *Glands* 7 mm. long, broadly cuneate, palmatifid, lobes 3-6, which are divided near the apex something like a reindeer's horn. *Ovary* peduncled, 5 mm. long, 5 mm. in diameter, glabrous; style united for 2 mm., and then divided into 3 arcuate lobes about 4 mm. long; stigma terminal, capitate; peduncle 5-7 mm. long, glabrous.

Transvaal: Lydenburg District, Lydenburg. *Jeppe* in *National Herb.* 1052. Flowered in garden, Division of Botany, Pretoria, Jan., 1919. *Garden No.* 6619.

This species of *Euphorbia* is a native of Angola and Tropical Bechuanaland, and living plants were first sent to Kew in 1864 by Mr. Joachim Monteiro. It flowered in the Cactus-house at Kew the following year, and was then described and figured by Hooker in the *Botanical Magazine,* t. 5534. Our plant was sent in by Judge Carl Jeppe, who has contributed many valuable living specimens to the Division of Botany. It was collected at Lydenburg, in the Transvaal, and flowered at Pretoria in January, 1919. This is the first record we have of this species from South Africa, and it is not mentioned in the recently published monograph in the "Flora Capensis" on the genus *Euphorbia.* For the identification of the species I am indebted to the Director of the Royal Botanic Gardens, Kew.

SOME NATIVE EDIBLE FLESHY FRUITS REPRESENTED IN THE MUSEUM OF THE NATIONAL HERBARIUM, PRETORIA.

Miss K. A. Lansdell.

(Title only.)

WITCHCRAFT: THE GREAT OPPOSING FACTOR TO PROGRESS.

By Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.

(Title only.)

THE PLACE OF CATTLE AS A FACTOR IN NATIVE ECONOMIC DEVELOPMENT.

By Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.

(Title only.)

AN ENQUIRY INTO THE ORIGIN AND DERIVATION OF CERTAIN SOUTH AFRICAN PLACE-NAMES—II.

By Rev. C. Pettman.

Read July 10, 1919.

It is not a little gratifying to see that the origin and derivation of our South African place-names is a subject that is evoking increasing interest among those who are in a position to push their inquiries and investigations in quarters and directions that are closed to most of us. The valuable papers on Bantu place-names, contributed by the Rev. J. R. L. Kingon and the Rev. W. A. Norton, which have appeared in recent Reports of the Association, and the equally valuable little work on "Place-Names in the Cape District: their Early Origin and History," by Mr. C. Graham Botha, of the Cape Archives Department, are sufficient to indicate how rich in historic and other interest this field of research will prove if followed up by enthusiastic concentration upon definite areas with which the enquirier is familiar.

The object of this paper, like that of the former (Report S.A.A.A.S., 1915, p. 159), is to place on record some further points of interest that have occurred as the result of enquiries into the origin of place-names found on various maps of Africa or of the sub-continent.

Some of the older names on our maps have so changed in form and appearance as to obscure the first meaning of the name, and, at the same time, have become, in their latest form, suggestive of an entirely wrong derivation. Take the name of the river known to-day as the Bot River. Burchell ("Travels in South Africa," 1822, i., p. 93) mentions this river, and against the name "Bot River" he places in brackets and with a query the word ("Flounder?)"; obviously the meaning of the name was not apparent to him. According to the Dutch dictionary the word *bot,* as a substantive, may stand for one of four very different things; in addition to which it may be an adjective, the meaning of which does not appear to be connected with that of any one of the substantives. Burchell suggests as the possible origin of the name of the river the word meaning a plaice or a flounder. In view of such river names as Steenbras, Kabeljauws, etc., this does not appear to be an impossible origin, until we begin to trace the name back. So doing we find that Thunberg ("Travels," 1795, i., p. 217) gives the name of this river as "Booter-river." Then on the "Plan of Baay Fals," by Captain R. F. Gordon, dated December, 1780, the name appears

as "Boter Rivier," which name it also bears on the "Kaart wegens de Landtocht van de Caap de Goede Hoop, na de Amaquas, alsmede van de Caap voorn, na de Caap das Anguilhas in den jare 1682"; that is a hundred years earlier still. There we find William Ten Rhyne, who visited South Africa in 1673, gives this river the name "Butyrosum" ("Boter River"). Thus Boter Rivier would seem to be the earliest form of the name now contracted to Bot Rivier.

But why Boter Rivier? There can be little doubt that this is the Dutch rendering of the earlier Hottentot name of the river Gouga (Hot. *gou*, to be fat; *ga* = *xa*, the adjectival ending indicating abundance, quantity).

Whence the name of the small bay within Saldanha Bay, known as Hoetjes Bay? In an early map of "De Baai vom Agoa de Saldanha," in the collection of Mr. van Gijn, Dordrecht, Holland, showing the position of the Dutch Fleet, under Admiral Lucas, in Saldanha Bay, when captured by Admiral Elphinstone (1796), the name of this bay is given as "Odjens Baai."* Earlier, on Bowen's map (1744), the name appears as "Oetiens Bay."

* See Molsbergen and Visscher, "South African History told in Pictures," 1913, p. 58, where the map is reproduced.

Then on a map reproduced by Molsbergen ("Reizen in Zuid-Afrika in de Hollandse Tijd," 1916, i., p. 26) this bay is marked "Oedekens Baey of Hoetjes Baey." Are these various spellings of the name of the Bay so many corruptions of the family name of the "Oetgens van Waveren te Amsterdam," in honour of whom Governor Willem Adriaan van der Stel changed the name "Roodezand" to that of "Waveren" for the South-Western division of the Cape Province, now known as Tulbagh? If not, what does the name "Hoetjes" mean?

A mountain gorge in the Caledon district, through which road and rail pass between Cape Town and Caledon, is now known as Houwhoek. But the name has appeared in several forms in the past, each having a different meaning. Thunberg ("Travels," 1795, i., p. 217) gives the name the form "Houthoek"; Lichtenstein ("Travels in Southern Africa," 1815, ii., p. 120) has the form "Houhoek," which he renders "the Halting-place"; Burchell ("Travels in the Interior of South Africa," 1822, i., p. 92, n.) says:

> "This word has been spelt in various ways, according to its supposed etymon: Houwhoek, implying 'Hewing-corner,' Houdhoek, 'Holdfast-corner,' or Houthoek, 'Wood-corner.'"

There he leaves the matter without any suggestion as to the correct form, which appears to be still a moot point. It would be interesting to know what were the reasons, if any, that induced the Government to adopt the present accepted spelling of the name, the earliest form of which appears to have been "Houthoek"—so, at least, Molsbergen ("Reizen in Zuid-

Africa," ii., p. 20) spells it in his account of Jan Hartogh's landtocht in 1707.

The name given by Vasco da Gama to the coastal country immediately south of Delagoa Bay—TERRA DOS FUMOS—is usually derived from Portuguese *fumo*, smoke; and is explained as referring to the grass-fires which the early voyagers saw as they sailed along the coast, by which the natives destroyed the old and dry grass. But in the Journal of Vasco da Gama's Voyage there is no reference at all to such grass-fires. There is, however, a reference to the "many chiefs" found among the peoples occupying this territory; and, according to Bleek ("Languages of Mozambique," published at D'Urban, Port Natal, 23rd May, 1855), the Tette, Sena, and Quilimane name for a chief, or headman, is still the word *fumo*, and the Maravi name for a king is *mfumo*. Ravenstein ("A Journal of the First Voyage of Vasco da Gama, 1497-1499," p. 17, 1898), referring to the remark in the Journal:

"This country seemed to us to be densely peopled. There are many chiefs,"

has the following footnote:

"Hence called 'Terra dos Fumos,' or, more correctly, 'Mfumos,' the 'land of petty chiefs.' . . . The appellation has nothing to do with either 'smoke' (fumo) or 'moisture' (humor)."

On Blaen's map, 1665, this territory, the present Amatongaland, is thus designated. On Bowen's map, 1744, the name is given to all the coast country from Natal to Delagoa Bay.

There is a river which runs through the Aliwal North and Barkly East districts which is marked on our maps as the KRAAI (D. crow) RIVER. This name is, however, a corruption of the English name Grey's River, which was given to it by Colonel Collins in 1809, as appears from the following:

"As no colonist had been here before, and the country was destitute of inhabitants from whom we could learn the name of the river, if it had any, we honoured it with that of Grey's River."—"Journal of a Tour to the North-Eastern Boundary, etc., by Colonel Collins in 1809." See Moodie, "The Record," Part v., p. 3.

"In a few hours after leaving the Stormberg, we found our course intercepted by a strong stream, then rendered impassable by the heavy and continued thunder-storms. To this stream the Commissioner gave the name of Grey's River (since corrupted into Kraai River), after General Henry George Grey, then commanding the troops, and afterward Acting Governor of the Colony."—Stockenstroom, "Autobiography," i, p. 41, 1887.

Stockenstrom, it may be remembered, accompanied Colonel Collins on his tour as Commissioner-General in the capacity of interpreter and secretary. In the map in Stockenstrom's first volume the name of the river is given as Gray River, and this is how it is spelt by Gibson ("A Manual of the Geography of British South Africa," 1852, p. 43). Kraai Rivier has now entirely superseded the earlier name, and at one time gave its name to the district.

In a somewhat similar way the name of the mountain of the Amatola range—GAIKA'S KOP—conveys an idea that does not belong to it. In its present form the name appears to refer to an individual, when originally it was void of any such reference. The native name of the mountain is *Ntab'egqira*, which means "the witch-doctor's mountain"—the iGqira is a native doctor who professes to discover those who bewitch. The name has no connection, other than an etymological one, with the name of the once powerful Gcaleka chief, known to the colonists as Gaika. The fact that the proper name of this chief was Gqira seems to have misled the colonists, who have given a personal reference to the name Gaika's Kop, when its original reference was to the functionary. During the Kaffir War of 1835 an attempt was made to supersede this name by another:

"The most conspicuous object in the scene was the lofty conical mountain called Gaika's Cop or Quira (Luheri), "the doctor," the head-quarters of lions, and now named after our physician, 'John Murray's Hill,' a high compliment to the chief of our medical department."—Alexander, "Narrative of a Voyage of Observation," etc., 1837, ii, p. 242.

The earlier name, in its corrupted form, survived this attempted change.

There is a small place in British Bechuanaland the name of which appears on the map as GROOT KONING, and at no great distance there is also a KLEIN KONING; these places are situate to the south-east of Kuruman. The names are thus given on J. Templer Horne's "Hydrographical map of the Cape Colony," 1895. The name appears also in the form Koning on the map in Stow's "Notes on Griqualand West," 1875. But, notwithstanding the Dutch appearance of the name, it is nothing other than a corruption of the native name of the place Kgoning, from Sechuana, *dikgoñ*, sticks, firewood, and means "the place of firewood." The name has made one jump from the hearth to the throne.

There are one or two place-names that occur more or less frequently on early maps, and in early accounts of the Cape, of which the physical features to which they were appended appear to be in doubt. So far as the name is concerned, CAPE FALSO has disappeared from modern maps. The question has arisen as to its exact locality. Early voyagers, travellers, and geographers could scarcely have succeeded better had it been their intention to mystify us. Pigafetta ("A Report of the Kingdom of Congo, a Region of Africa, and of the Countries that border round the same. Drawn out of the Writings and Discourses of Odoardo Lopez a Portingall." By Philippo Pigafetta. Translated out of the Italian by Abraham Hartwell, London. Published by John Wolfe, 1597, p. 188) seems to place this Cape to the east of Cape Agulhas, while the map in "A Relation of the Voyage to Siam by Six Jesuits" (1688) places "Cabo Falso ou Cap des Aiguilles" at the western entrance to False Bay (the point which is our Cape of Good

Hope; this the authors have placed farther north, the name "Cap de Bonne Esperance" standing opposite what appears to be intended for the entrance to Hout Bay). But most of the 17th and 18th century maps (see maps by J. S., 1626, Delisle's "Carte d'Afrique," n.d., Delahay's map, n.d., Eman. Boven's map, 1748, M. l'Abbe de la Caille's map, 1763, "Hanglip ou Cap False") mark the Cape, now known as Cape Hangklip, as Cape Falso. Paterson ("Narrative of Four Journeys," 1789, p. 8) also applies both names to the same physical feature thus: "Next morning we continued our journey round the Hang Lip, or Cape False." Sparrman's map, 1785, marks Hanglip, and then further to the south-east, about where Danger Point should be, he marks the "False Hanglip." Le Vaillant's map places a "Valse Hanglip" at the same point as Sparrman, but ignores the real Hanglip altogether; and "Latrobe's map, 1818, marks "Cape False or Hangeklip." Query: Where was the original Cape False?

Another interesting point arises as to the origin of the name False Bay. Percival ("Account of the Cape of Good Hope," 1804, p. 41) says: "False Bay is so called from Cape False"; but Thompson ("Travels in Southern Africa," 1827, p. 429) gives the name False Bay another origin:

"False Bay, so called from ships having often been deceived in coming from the eastward. After rounding Hanglip, in darkish weather, imagining that they had passed the real Cape of Good Hope, they stand to the north, when in a short time they find themselves on the Muizenberg beach at the bottom of False Bay."

A puzzle of a somewhat similar character is as to the exact locality of the Penedo das Fontes (Port. *penedo*, a rock; *fonte*, a fountain or spring). This name is said to have been given by some of Diaz' people to an island in Algoa Bay, which Diaz himself (1486) named "Ilheo da Santa Cruz," now known as St. Croix. The name refers to two springs of fresh water found on the island—see Duarte Pachaco, "Esmeraldo de situ Orbis," p. 94. Theal ("The Portuguese in South Africa," 1896, p. 83) says that the island is often mentioned by this name in ancient books. But Perestello, who made a survey of the coast in 1575, from Table Bay to Cape Correntes, identifies the Penedo das Fontes with the "Ship Rock," a few miles to the south-west of the Kowie River. There are certain rocks in the neighbourhood which are known as the "Fountain Rocks," which name is supposed by some to be the lineal descendant of the Portuguese "Penedo das Fontes." It must be said that at present it appears to be somewhat of an open question as to which of these two places (*i.e.*, the island of "St. Croix" in Algoa Bay, or the "Fountain Rocks" near Port Alfred) was the real "Penedo das Fontes." Professor Schwarz's paper on the subject (Report S.A.A.A.S., 1912, p. 103) is scarcely conclusive. What a pity that the scraps of paper found in the box which was unearthed at the Kowie, of which he speaks,

were destroyed before being subjected to careful expert examination. They might have proved worthless, but there was the possibility of something being deciphered that might have been of inestimable worth to the student of Cape history. But when, why, and by whom was the Portuguese name "Santa Cruz" changed to the French "St. Croix"?

In 1686 a small book of 76 pages, in Latin, was published, the author being William Ten Rhyne, being an account of the Promontory of the Cape of Good Hope, in which we find the following passage:

Ατελεύτετον, seu 'sine fine flumen,' (Rivier sonder eynde) ex montibus ortum hactenus, quousque se extendat, ignotum" (pp. 11, 12).

Nineteen years later (1707) this work was translated into English, and included in Churchill's "Collection of Voyages," the above passage reading:

"The Endless River, it rises in the mountains, but its extent is unknown hitherto" (iv, p. 831).

In 1688 an English translation of a French work ("A Relation of the Voyage to Siam, performed by Six Jesuits") appeared; it contains a "Carte des Pays et des Peuples du Cap de Bonne Esperance," on which a river is marked, "Fleuve sans Fin," which runs into "Le Fleuve Large." So far as this map is concerned, these are the only two rivers on the eastern side of the sub-continent, which are named, and they are figured as discharging into the Indian Ocean, nearly as far north on the eastern coast as the Olifants Rivier does into the Atlantic Ocean on the western coast. The reference in each of these two works is to that branch of the Breede Rivier, which has its rise in the Fransche Hoek mountains, and then traverses the entire length of the Caledon district, and still bears the name ZONDEREINDE RIVIER. Lichtenstein ("Travels," 1812, i., p. 151) says that the name was given by the persons who first discovered the river, "because they found it a very great labour to trace it to its source." While Burchell ("Travels," 1822, i., p. 303) informs us that "the course of the river is by no means of such a length as to justify the name it bears." But according to 18th century maps this was not the only river of South Africa that claimed the distinction of being "without end"; for on Delisle's "Carte d'Afrique," 1739, it is said of a river which is represented as running into the River de St. Christopher (St. John's River of the present day), "River sans finis"; and Bowen's map of Africa, 1748, says of the same branch of the same river: "This river is said to have no end." Whether this was another "Endless River," or a shifting of the locality of the former, who can say? If the latter, it was a mistake.

The origin of the name HOTTENTOTS HOLLAND appears now to be definitely settled. Molsbergen ("Reizen in Zuid Africa,"

1916, i., p. 26), having had access to the original document in the Kolonial Archieftes' Gravenhage, gives the origin thus:

"Drie Kolonisten waren buiten weten van de Kommandeur 'omtrent 15 uyren gaens meest snyden te landewaerts in geweest.' Hottentotten, omgeveer 5 á 600 zielen, troffen ze aan in een vruchtbare streek, ende noemende deze gemelte plaatse, als zijnde seer vette weyden, haer Hollandt, offte Vaderlandt om d'onze te better te verstaen te geven de volheyt van spijse offte treffelijcke weyden voor haer bestial, daar gelegen."—"Kaaps Dag-register," 6 June, 1657.

A question has arisen as to who gave the name Cape of Good Hope, or, in its Portuguese form, Cabo de Bona Esperanza, to our promontory. Who really gave this name to our Cape? Tradition has it that when first discovered by Diaz, 1486, he gave to this Cape the name "Cabo Tormentoso," because he was unable to weather it on account of the heavy storms that prevailed there; subsequently, however, he doubled it without being aware of it at the time. Tradition says further that King John II of Portugal, seeing in this doubling of the Cape the promise of a new route to the wealthy Orient, changed the name to "Cabo de Bona Esperanza." But Pigafetta (p. 190) says:

"It is called the Cape of Good Hope because all such that saile that way, as well in going forth as in returning home, doo especially and principally ayme at this marke, that they may pass and get beyonde this Promontorie, which when they have done they account themselves to be out of all daunger, and as it were to have performed their journey. And upon this their generall desire they give it the name of the Cape of Good Hope."—"A Report of the Kingdom of Congo," etc., 1597.

It is of interest to remember here that Pigafetta acknowledges "Odoardo Lopez a Portingall" to be the source of his information. But, in addition to the doubt which Pigafetta's statement would seem to cast upon this particular story, the following remarks by Ravenstein ("Geographical Journal," 1900, p. 641) make it still more dubious as an historical fact:

"We fancy that this (the changing of the name by King John) is one of those pretty legends frequently associated with great events, and Barros appears to be responsible for the same. Pachaco, a contemporary, says that it was Diaz who gave the Cape its present name, and Christopher Columbus, who was present when Diaz made his report to the King, says the same."

In 1605, nearly 50 years before Riebeeck landed at Table Bay (1652) and proclaimed the country Dutch territory, Sir Edward Michelbourne gave the name Coney Island to the island that is now known as Dassen Island—in each instance the name has reference to the same small animal, *Hyrax capensis*. In the Journal of Sir Edward Michelbourne's Voyage contained in Purchas ("His Pilgrimes," i., iii., 133) we read:

"Upon the said island is abundance of great Conies and Seales, whereupon we called it Cony Island."

It is amusing to read what Sir Thomas Herbert has to say some 60 years after as to the origin of this name ("Some Years'

Travels into Divers Parts of Africa and Asia the Great," 1665, p. 13):

We could not reach the continent, but we dropt our anchor 14 leagues short of *Souldania Bay* (*i.e.*, Table Bay) afore a small isle call'd Coney Isle, through corruption of speech, the proper name being *Cain-yne* in Welsh of that isle."

But he vouchsafes no information as to how the island came to have a Welsh name, nor what was its meaning.

By the early Portuguese navigators this island was named Ilha Branca (Port. *branca*, white). In 1601 Joris van Spilbergen gave it the name of Ilha Elizabeth:

"1652, October 21st.—Left this morning—anchored at night under Ilha Elizabeth, named so by Joris van Spilbergen in 1601, and also called Dassen Island."—"Riebeeck's Journal," Leibbrandt, 1897, Part I., p. 30.

This last name—Dassen Island—won through.

There is a range of mountains in Great Namaqualand, the Hottentot name of which is *!Han ǂami*, meaning "Red veldbulb Mountain." (Hot. *'Hani, Wachendorfia* sp.). As this name is spelled by Alexander ("Expedition of Discovery into the Interior of Africa," 1838, i., pp. 259-260), the ordinary reader would scarcely recognize it as an attempt to reproduce the Hottentot name, and yet that it is such an attempt there can be no doubt:

"From Tuais we saw the long line of the 'Un'uma or Bulb Mountain, two or three thousand feet high, east of us, and between us and them was the Koanquip, a branch of which was the Gnuanuip."

In this spelling the commas represent clicks, but on Alexander's map the name appears in the form Unuma, without commas.

There is little, if anything, in Alexander's form of the name to suggest our familiar colonial place-name HANTAM, and yet Alexander's "Unuma" and our "Hantam" are both of them attempts to reproduce the Hottentot !Han ǂami, and all three are to be regarded as meaning "Red bulb Mountain."

The name of the great waterfall, or series of waterfalls, on the Orange River, situate to the west of Upington, Gordonia, C.P., known as the AUGHRABIES FALLS, has fortunately survived several attempts to supplant it on the part of explorers and travellers. The earliest reference to it by this name appears to be in the "Gesigt van het land op de 28ste graad, 32 min. Zuid, 3 gr. oost lengte van de Caap de Goede Hoop, beneden de Groote Waterval Aukcerebis, in Oranje Rivier, of Garieb, in het Einiquasland." ("Gordonverzameling No. 42." Rijks Prentenkabinet te Amsterdam.) It is also mentioned as "de magtige groote waterval," by Hendrik Jacob Wikar, who accompanied Governor Joachim van Plettenberg on his journey to the Orange River, in his account of that journey, dated "Cabo den 18 September, 1779." He describes the spray-cloud, the precipice, and the noise of the foaming water:

"Hier van de Hamis is circa 2 uur te voet na de rivier, daar is de magtige grootewaterval die men in de droogen tijd by helder weer op een

schoft ver en ook wel verder als een vuurrook zien kan, op mijn oog zou de heele rivier van een klipkrans afstorten 2 maal zo hoog als 't casteel hier is . . . kan men 't gedruys als een bruyssende zeë ook wel op een schoft ver hooren; en een half uur booven deze waterval, is 't water zeer sterk van trek."

Later travellers who have visited these Falls seem to have regarded it as an imperative duty to attempt to supersede the descriptive native name, Aughrabies (Hot. ||*orab,* a rocky waterfall), by names that might have been good enough had the falls been without a name. Thompson, who visited these Falls in 1824, gives a graphic description of them ("Travels and Adventures in Southern Africa," 1827, p. 264), and concludes by saying:

"I named this scene 'King George's Cataract,' in honour of our gracious Sovereign."

Farini ("Through the Kalahari Desert," 1886, ch. 23 and 24) is no less enthusiastic over the grandeur of the scene which the Falls present, of which he furnishes a map, but cannot refrain from trying his hand at beautifying (?) our South African nomenclature by giving names to individual falls of the series, and concludes by naming the whole "The Hundred Falls" (p. 417). Aughrabies let it be.

There are a few comparatively recent place-names that also call for notice. Mowbray is one that seemed to be somewhat of a mystery. The following notice appears in the *Government Gazette,* Colonial Office, Cape of Good Hope, 17th June, 1850:

"His Excellency the Governor having been pleased to comply with the request made to him by the inhabitants of the village of Three Cups, in the Cape Division, to change the name to 'Mowbray.' Notice thereof is given for general information.

"By Command of His Excellency the Governor.

"John Montagu,

Secretary to the Government."

Mr. Butler, the then proprietor of an inn at this village called the "Three Cups," hailed from Melton Mowbray, England. It was due to him that the request was formulated and presented to Sir Harry Smith, the Governor, on behalf of the residents in the village, that the name should be changed. His inn was subsequently known as the "Mowbray Inn."

Another name that has yielded its secret is Ceres. It may be remembered that in a previous paper (Report S.A.A.A.S., 1915, p. 170) reference was made to the several suggested origins of this South African place-name, no one of which could then be pronounced authentic. It now appears that the place is indebted for its classical and appropriate appellation to the father of Senator Munnik. Compelled by reasons of health to leave Worcester, where he had resided, Mr. Munnik removed to this part of the Bokkeveld, and purchased the farm upon which the present township stands. The village, laid out later, received from him the name of the goddess of Agriculture, Ceres, in recognition of the fertility of the soil in this locality.

Trollope ("South Africa," 1872, i., p. 133) says:

"The name Ceres has been given to the valley in a spirit of prophecy which has yet to be fulfilled. The soil no doubt is fertile, but the cereal produce is not yet large.

The suggestion of the name has passed into fact.

In 1839, one year after Retief and his companions were so treacherously slaughtered by the Zulu chief, Dingaan, the Voortrekkers of Natal had laid out a township, which is still the chief town of the Province. The name PIETERMARITZBURG is generally regarded as being a compound of *Pieter* (Retief and Gert) *Maritz*, two of the Voortrekker leaders. The name appears, however, as early as 1840, in the form Pietermaritzburg:

"January 18th, 1840.—"Er werd dan gevolglyk een expresse met Veld-Kornet Bester naar den Landdrost van Pietermauritzburg, gezonden."—"Expeditie of Dagverhaal van de Expeditie der Emigranten te Port Natal," Kaapstad. Gedukt ten Kantoor van "De Zuid Afrikaan," p. 3, 1840.

Preller ("Piet Retief," 1912, p. 295) reproduces a letter written by Retief's widow to Gideon Retief, her brother-in-law, dated:

"Op de Kolonie van Port Natal, genaamt Pieter Mouritz Burg," den 7 July, 1840."

In 1851 Freeman ("A Tour in South Africa," 1851, p. 349) spells the name Pietermauritzburg.

Referring to this spelling of the name, Professor Cachet ("De Worstelstrijd der Transvalers." 1822, p. 210, n.) says that "oude voortrekkers" had told him that that was the correct spelling. He was assured that the original intention was to name the town after Pieter Mauritz Retief only. But, unfortunately for this latter statement, Mauritz does not appear to have been any part of Retief's name, as appears from a certified copy of the entry of Pieter Retief's baptism, which is reproduced by Preller ("Piet Retief," 1912, p. 2). Maurits and Mouritz seem to be simply variants of Maritz.

The conspicuous features of the city's coat of arms are an elephant and the Zulu word Umgungundhlovu, meaning "the place of the elephant." This was the name of the "great place" of the Zulu leaders Chaka and Dingaan. Chaka was styled by his people "The Elephant" (Z. *in Dhlovu*), a title which Dingaan, his brother, murderer, and successor, assumed. Later, this name was transferred by the natives of Natal to Pietermaritzburg as being the seat of Government and the capital of the Colony (now Province); hence its appearance with the elephant on the city's coat of arms.

A small township on the Little Marico River, Western Transvaal, founded in 1868, and made into a magistracy in 1871, is named ZEERUST, a name the form of which suggests a derivation very different from its real one. How there could be a *Zee*-rust so many hundreds of miles from the shore of either

ocean or lake was a perplexity, until it was unravelled for me a few years ago by a friend who had lived many years in that part of the country. The owner of the farm upon which the township was laid out was surnamed Coetze, and the place-name was formed by appending *rust* (rest) to the last syllable of the surname. This derivation appears to be supported by the fact that on Jeppe's map of the Transvaal ("Journal of the Royal Geographical Society," 1877, p. 217) the name Coetzee is inserted immediately beneath the name Zeerust.

As late as 1911 the old fort, with deep loop-holes, built by the Voortrekkers at this spot, was still standing, but to some-one's lasting discredit this old building, with its interesting historic associations, had to make way for a magistrate's office. Want of imagination discovers itself in a great variety of ways, and in South Africa the utilitarian appears to have precedence nearly always and nearly everywhere.

But perhaps nowhere is the lack of imaginative insight more conspicuous than in some of our place-names. To give one example only: Wolraad Woltemade, with his noble horse, succeeded in saving 14 men from the wreck of *de Jonge Thomas* during a heavy storm in Table Bay, June 1st, 1773. Seven times he swam his horse through the breakers to the wreck, and seven times he returned with two of the wrecked people, losing his own life on his eighth effort to save more. The application of this hero's name to a succession of cemeteries just outside Cape Town is only one instance, among many, of the utterly incongruous in our South African place-naming. These cemeteries, until a few years ago known as the Maitland Cemeteries, because of their proximity to the village of that name, are now known as the WOLTEMADE Cemeteries. Why this change appears to be beyond guessing; for the hero of as noble and self-sacrificing an instance of life-saving as our Cape history can chronicle to be honoured (!) by having his name attached to the place of the dead seems to reveal an almost unpardonable lack of the sense of congruity.

There are other South African place-names that one would like to discuss, but they must wait another opportunity, and, some of them, further enquiry. A great deal of sifting of evidence is needed in many cases before anything like satisfactory conclusions can be reached: for early writers are too often unsound in their derivations of our place-names, and local authorities are, nearly as frequently, uncertain in theirs. But the work of research is not without its adequate compensations.

TRANSLATION OF CENTRAL AFRICAN FOLK-LORE TALES.

BY J. MCLAREN, M.A.

(Title only.)

M. Wilman. -The Engraved Rock of Kopong and Loe, Bechuanaland Protectorate.

M. Wilman.—The Engraved Rock of Kopong and Loe, Bechuanaland Protectorate.

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M. Wilman. The Engraved Rock of Kopong and Loe, Bechuanaland Protectorate.

THE ENGRAVED ROCK OF KOPONG AND LOË, BECHUANALAND PROTECTORATE.

By M. Wilman,
McGregor Memorial Museum, Kimberley.

With Plates XL-XLIII.

Read July 9, 1919.

In a paper read at the last meeting of this Association* it was stated that another "Creation site" had lately been reported to Mr. J. D. Knobel, of Molepolole, and that he was making enquiries about it.

These having proved fairly promising, he very kindly invited Mr. A. M. Cronin and the writer to accompany him, last May, to a place called Kopong,† in the hope of being able to locate and photograph the spoors said to exist there.

Kopong is situated on the north of the Mokwena stad of Molepolole, some ten miles from it, but only about two miles from the Makgalegadi village of Mutle.

The latter is easily reached from the stad by ox-waggon along what is little better than a track through grass veld and rather thin bush.

Beyond Mutle, however, this becomes less thin, and the last part of the way, indeed, can only be made on foot through fairly dense bush. But suddenly this opens out and an extensive outcrop of quartzite is revealed, and here the Kopong may easily be discovered.

A large portion of the outcrop is well shown in one of the photographs taken by Mr. Cronin (Pl. XL). Here the rock is seen sloping down towards the hole, in the foreground.

Over it in the rainy season large quantities of water must rush down and collect at the base to form a water-hole; but in May last, after long-continued drought, there was no water there, only much sand, almost closing the hole.

Some of the rock is very coarse, and none of it is fine-grained, but it has been much weathered, and on the slopes leading to the hole it has in addition been worn down by humans and animals in quest of water to such an extent that it is now quite smooth and slippery.

On the more or less horizontal rock in the distance (Pl. XL, XLI) spoors, with a notable exception, could not be found;

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*M. Wilman: "The Engraved Rock of Loë, Bechuanaland Protectorate." Rep. S.A. Ass. Adv. Sci., 1919, XV, pp. 531-534. Pl. 12-15.

† Kopong means "a round hole," and is a not uncommon place-name in Bechuanaland.

but at one spot there is a coarsely hacked-out circle less than 15 cm. in diameter.

On all the rock slopes, however, and especially along the trails, spoors innumerable were easily detected.

These occur sometimes singly, but more often in large numbers, close together, facing both towards and away from the hole, just as though herds of animals, in wending their way to and from the water, had left their imprints on the rock.

Unfortunately, wherever these occur on the actual trails they have been almost obliterated (Pl. XLI). But lying a little off the beaten track there are still a number that Mr. Knobel and the Bakwena "boys" were able to identify.

One well-defined group is reproduced here (Pl. XLII). In the foreground the spoors are quite distinct, especially the two, about life-size, of the eland. In addition, there are spoors of the hartebeest, kudu, lion, ant-bear, zebra and its young, and the baboon. In the background they are very indistinct, but only because they have become so in nature.

In the case of another group (Pl. XLIII) the spoors have been so smoothed down that only those of the eland and its young, the wildebeest and the zebra can now be made out.

Traces of humans were eagerly looked for, but with little success.

Near the eland spoors (Pl. XLII) there is what may have been intended to represent a set of human toes, and on the distant rocks, to the right of those photographed (Pl. XL), there is the exception above referred to—a small human foot, short and square-toed, like those at Loë.

The so-called spoors are, of course, engravings in the rock. In technique they closely resemble those at Loë, though the latter, on the whole, must have been more deeply engraved. This probably is the reason why they are to-day in a better state of preservation, not because they are of later date.

At Loë the engravings occur crowded round the water-hole, here they are scattered over a comparatively wide area; at Loë the actual number is smaller, and there seems to be less variety in the spoors. On the other hand, there appear to be here no representations of animals, and the human interest is almost lacking.

At Loë, again, the hole seems deep and suggestive of mystery, whereas here there is but a sand-choked hollow.

For this reason perhaps the Bakwena say that out of Loë came the Bechuana (including the Bakgalegadi), whereas out of Kopong came only the despised Masarwa.

Since the publication of the paper on "The Engraved Rock of Loë," Mr. Frank Cruden, of Alicedale, has called the writer's attention to an earlier version of the Loë legend that appeared at Lovedale in the *Christian Express* of August, 1903, pp. 122-123. As this publication is not met with in most libraries, a

typed copy of the paper was procured through the courtesy of Dr. W. A. Roberts, and is reproduced here:

A NATIVE LEGEND OF THE ORIGIN OF MAN AND ANIMALS, AS TOLD BY A NATIVE LAD.

When I was still a small boy, my parents told me that there is a very deep hole. This hole is where the people of the olden times are supposed to have come from. The name of the hole is Lowe. Lowe might be called a hole or a cave, because the hole is at the mouth of a cave. At the mouth of the cave there is a wide flat stone, stretching about half a mile all round the hole. The story of Lowe is as follows:—Long ago, when that stone was still soft and wet, a lot of people came out from that hole. Numerous tracks of wild beasts and many tracks of people can be seen, veld-schoens of the Bechuanas and Bushmen, and the footprints of dogs, lions, tigers, and a good many other beasts. These tracks are still there even now. Among those tracks of people there was a very long track of a man's foot, very wide also. This man was supposed to have led the people from there. They called him "Matsieng." The place where he trod is called "Neneke." It is not very far from Kanye. When they went out from that hole one nation went in one direction, and another in another direction; even the beasts and cows took their own directions. Of course, the cows took the same direction as their owners, and the dogs also. It is said before they went far the leader was told by God to gather the various tribes in one place, so that they could be given wisdom. He gathered them and encamped them on a certain place; the name of the place is not given. It is said that God told the leader that they must not go anywhere until he came back. The people were different in colour, but could speak the same language. About the middle of the day some vultures flew past above them. Matsieng saw those vultures. He knew that they flew to something dead. He broke the command of God and ran after them. The black people were not given so much as the white people, because they broke the command of God. From this time the black people went their way and the white people theirs. After they had gone their way, God wanted to punish the leader, so he was sent back to the hole. Since that time he has never come out. The hole is just in the centre of Bechuanaland, between Chief Khama's country and Chief Sebele's country.

Many people go to see that hole and those tracks. They told me strange things about the hole. What they say is this: When any person is near the hole, he can hear the voices of boys milking the cows or talking to each other, and the dogs barking, the lowing of the cattle and calves, just as one hears them when they are at a cattle-post. They also say that if a person throws a stone inside the hole at six o'clock in the morning, and goes away, if he returns next day, or two or three days after, he will hear the sound of that stone distinctly.*

A remarkable thing is that none of Matsieng's footprints can be seen facing either north, east, or south; they always face west. At Neneke his footprint is pointing towards the west, and in all those places where his footprint has been seen it is always the footprint of the right foot. Among the natives it is believed that when any stock gets lost, if they faced the east, it is a sure case that they

* With reference to this, Mr. J. D. Knobel writes: "I do not know Neneke. The place where a stone can be heard falling for a long time is a different place in Khama's country. The Rev. Willoughby visited it, and told me that the sound supposed to be that of the falling stone is made by the bats that inhabit the hole, called Sebonosanaga."

will never be seen again, unless they turn towards the west, where their owner has faced.

In the whole of Bechuanaland, when they carry a dead person to be buried, they carry him with his head towards the west, and bury him also with his head towards the west. The reason for this is that Matsieng faced the west when he came out from Lowe, and his children, when they die, are supposed to be following him.

POISONING OF CATTLE BY *DIPLODIA*-INFECTED MAIZE.

By D. T. Mitchell, M.R.C.V.S.,
Senior Veterinary Research Officer, Maritzburg, Natal.

Read July 10, 1919.

During recent years, in various parts of Natal, a number of cases of paralysis in cattle have occurred when the animals have been allowed access to mealie lands for grazing purposes in the latter part of the winter.

It is customary, in this Province, when harvesting mealies, to discard all cobs which are badly formed, and these cobs are either left on the stalk or dropped on the ground. In this way, when the cattle are changed to old lands, there are considerable numbers of old and damaged cobs lying around, which have been exposed to the weather for some months, and these are readily eaten by the cattle. Owing to this, and to the fact that the cobs are to be found in many of the districts in a very mouldy condition, it has been suspected by farmers, in areas where the paralysis among cattle occurs, that this condition is due to eating a large quantity of these diseased mealies. Positive experimental evidence on the subject was, however, lacking. Feeding tests, carried out at the Veterinary Research Laboratory, Pretoria, with material (mealies on cob) obtained in the Ixopo Division, Natal, failed to give any positive results. The animals used in these experiments were two sheep, two goats, one calf, and one mule. The experiments were continued for three weeks, during which time the calf, sheep, and goats received an average total of 33 lb. of cobs per week, and the mule 15.5 lb. per week.

During the last five weeks of the tests soaked mealies were given. One heifer was fed on a culture of the fungus, grown on crushed maize, for from one to one and a half months; this animal consumed 23 lb. of this material between the 19th and 31st March. No symptoms other than a slight loss of weight could be observed in any of the animals under observation.

From the subsequent experiments on *Diplodia*-infected maize it would appear that the quantities fed at Pretoria were too small to produce effects, or, what is more probable, that the supply of

cobs forwarded for experiment contained only a small percentage of infected grains.

Reference to these experiments will be found in a pamphlet (*Science Bulletin No.* 7), published in 1916 by Dr. van der Byl, of the Division of Plant Pathology. This pamphlet gives a detailed description of *Diplodia zeæ*, with photographs of infected maize cobs, and should be consulted by those interested in the following feeding tests.

From these previous experiments, it was concluded that the maize so infected had no harmful effect on animals to which it was fed.

Although these results were fairly conclusive, the experience of many farmers pointed definitely to the harmful results of allowing cattle to graze in those mealie lands where cobs were abundant, and for the first few days, at any rate, constituted almost the sole article of diet.

For this reason it was decided to commence a series of experiments at the Maritzburg Laboratory, utilising mealie cobs obtained from farms where the disease had recently occurred.

Through the assistance of Mr. Power, Senior Veterinary Surgeon, Natal, sufficient material was obtained for the tests from various farmers in the Estcourt Division. Some cobs were forwarded to the Government Botanist, Pretoria, for determination of the infecting fungus present, and were reported on by him as follows:—" The mealie cobs referred to in your Minute of 30th September last are infected with the fungus *Diplodia zeæ*."

For the tests four oxen were selected which had been on the station for about two years, and had been fed only on grass in the paddocks adjoining the Laboratory. These animals were about five years old, and in good condition. During the experiments they were tied up in the stable, and watered by hand with water obtained from the river close by. The mealies on the cob were fed as received from the farmers, but in all cases only the mealie grains were eaten, the central core being rejected. It is therefore difficult to say definitely what weight of material was actually eaten.

Quantities of material fed:—

Ox 88	360 lbs.
Ox 90	270 lbs.
Ox 94	225 lbs.
Ox 87 ... ... *ad lib.*, about	145 lbs.

Of these four animals one ox did not show any symptoms, and the remaining three developed typical symptoms.

General Notes on the Experiment.

With the exception of Ox No. 87, the feeding on the mealie cobs was discontinued as soon as the first symptoms were shown.

In the case of this latter animal the feeding was continued up to the time of death. It is considered that, had the feeding of cobs been discontinued when symptoms of improvement were shown, death would not have ensued. In the other animals under experiment no medicinal treatment of any sort was administered, and the recovery in their case is attributed to the fact that, as soon as the first symptoms of paralysis or inco-ordination of movement were first observed, the animals were not given any more mealie cobs. The additional ration of sugar cane which was administered in their case could not be supposed to have any special curative influence other than that exercised in general by the good nursing which was accorded to the cattle. The quantity of cobs fed to the experimental animals was considerable. In the case of Ox No. 87, it was observed that although this animal consumed the smallest quantity, it was followed by fatal results, and that, although a similar quantity of mealie cobs of the same lot was fed to animal No. 94, this animal recovered. The effect produced would doubtless depend on the degree of infection of any particular lot of cobs with fungus; but, in view of the above-mentioned fact, it would appear that the particular idiosyncrasy of the animal was also a determining factor.

The general health of the animals in experiment did not seem to be greatly affected. The appetite was well maintained, and, with the exception of a slight degree of diarrhœa in the earlier stages, no derangement of the stomach or intestines could be noted. In the later stages constipation was present.

Practically no elevation of temperature was noted, and it was on this account, associated with the fact that the appetite was maintained well throughout, that there was such a slight loss of condition in the animals during experiments.

The foregoing experiments demonstrated conclusively that the feeding of oxen with mealie cobs infected with *Diplodia zeæ* produced a condition in the laboratory experimental animals which was indistinguishable from that occurring in cattle which gained access to mealie lands, and it was therefore concluded that the conditions were one and the same. As it was still not possible to say what was the actual exciting cause of the intoxication—whether it was due to the fungus, to the products of its metabolism, or to alterations in the starchy content of the grain on which the fungus was growing—a series of experiments were undertaken to elucidate this point.

Through the kindness of Dr. van der Byl a pure culture of *Diplodia zeæ* was obtained, and a number of preliminary experiments undertaken in order to ascertain under what conditions the fungus could be grown in bulk on maize, etc.

After some preliminary work it was found that the *Diplodia* would grow well at 27° C. in Mason's fruit jars filled with sterile maize. The lids of these jars had a half-inch opening drilled through to allow for inoculation of the medium with fungus spores. Growth was allowed to proceed for two months.

Notes on the Experiments.

Of the three animals which partook of the culture of *Diplodia* on sterile maize, in quantities of 20 lbs. each, two developed symptoms.

These symptoms resembled those produced by feeding on infected cobs, but the onset after the commencement of feeding was shorter, and the symptoms were much more acute. The period during which clinical symptoms were shown was shorter and recovery more rapid. These differences can be accounted for by the fact that the animals received a large dose of more highly concentrated material than was the case in the cob-fed animals.

The absence of symptoms in one ox may have been due to a tolerance resulting from an attack in the preceding year.

Conclusions.

From these experiments it was concluded that a condition, indistinguishable clinically from that produced by feeding on infected cobs or occurring naturally in infected mealie lands, could be set up by feeding on a culture of *Diplodia zeæ* grown on sterile maize.

Further experiments were carried out to determine whether allied species of fungi (*Mucor*), grown under similar conditions, would produce similar symptoms, and whether *Diplodia zeæ* grown on a cellulose medium would give rise to a similar condition when the medium was fed.

All these experiments gave negative results.

General Conclusions.

(1) That a disease in cattle characterised by inco-ordination of movement and paralysis is set up by feeding on mealie cobs which are infected with *Diplodia zeæ*.

(2) The cultures of *Diplodia zeæ* grown on a sterile maize when fed produce clinical symptoms indistinguishable from those set up by feeding on infected cobs.

(3) That the intensity of the symptoms and the mortality depend upon the quantity fed and on the percentage of infection present in the grains.

(4) That cultures of allied species of fungi grown on maize are incapable of setting up similar clinical symptoms.

(5) That the causal factor is not the fungus itself, but must be looked for in the material which is formed as a result of the interaction of *Diplodia zeæ* during its development in the starchy content of the maize grains.

A brief description of the disease as it occurs under veld conditions is herewith given.

General Account of Diplodia Poisoning in Nature.

Geographical distribution:

In Natal the reports of the presence of the disease would appear to be limited to the high veld parts of the country, and in these areas the occurrence of a disease in cattle resembling this condition have been very common during the last two seasons. In most cases it has been impossible to eliminate entirely all other factors, such as poisoning by poisonous plants, etc., owing to lack of opportunity to investigate each outbreak that is reported, but it may be taken that cases of the disease have occurred in most of the high veld mealie-producing centres of this Province. The losses have been most severe during the last season in the Estcourt Division, and it was from this district solely that the material was obtained for experimental purposes. Reports of a few outbreaks have also come to hand from the Ixopo Division, but material obtained from this district failed to reproduce the disease in animals at the Research Laboratory, Onderstepoort.

Seasonal occurrence:

The disease is limited to the late winter months, July to September. This is the period when veld grazing is very scanty, and it is the custom for farmers to turn their cattle at this time into the mealie lands for better feed.

Animals affected:

The disease is limited to cattle, animals of all ages and sexes being equally susceptible. Some reports have mentioned the fact that sheep were also susceptible, but up to the present it has not been possible to confirm this. Horses, mules, and donkeys would not appear to be susceptible, as these animals graze over the same area where cattle are dying of the disease without suffering any harmful results. No cases have been recorded of goats or pigs having been affected.

Cause:

The disease is only found associated with mealie lands, and it is popularly supposed by the farmers of the affected areas that it is caused by feeding on mealie cobs which have lain for some months on the ground. In the experimental investigations mealies which had been subjected to these conditions were found to be capable of producing a similar train of symptoms, and this supports the opinion of the farmers. Examination of the cobs fed revealed the fact that a very great percentage were infected with the fungus *Diplodia zeæ*. Experimental evidence has shown that cultures of *Diplodia zeæ* in sterile maize, when fed to animals, can set up clinical symptoms which are indistinguishable from those shown in animals contracting the disease naturally, and further experiments indicate that the results are produced by a

substance of, at present, unknown composition formed during the growth of the fungus in the maize grains.

Time after exposure at which the first symptoms are shown:

In natural conditions in the veld, cases have been known to occur in six to eight days after the animals were placed on the lands. In the laboratory experiments the shortest time which elapsed between the commencement of feeding on the cobs until the first symptoms were shown was three days, and the longest fifteen days. The animal which developed symptoms in three days was a very ravenous feeder, and this may account for the short time which elapsed before symptoms were shown. It may be taken that the development of the symptoms depends on the quantity eaten and the condition of the cobs with reference to their degree of infection by the fungus.

Symptoms:

The first symptoms noted are lachrymation and salivation, accompanied by slight quivering of the muscles of the flank and shoulder. The back is slightly arched, and the animal stands with its legs farther apart than normal. The head is carried low, and the ears droop slightly; the fæces are mostly soft, but no diarrhœa is present. In this stage, if the animal is walked, only slight symptoms of inco-ordination of movement are to be noticed. Later these symptoms are aggravated; profuse salivation and lachrymation are apparent; muscular tremors become general. The coat stares; the back is very much arched, and the animal has a dejected appearance. Progression is slow, and the animal only walks when compelled. Symptoms of in-co-ordination of movements are evinced by high stepping of the legs. Lateral swaying of the body occurs, and there is sometimes a tendency to progress with the hindquarters bent to one side. The animal falls after walking a short distance, unless supported. These symptoms last for about one or two days, after which the animal is unable to rise without assistance, and, when lifted, stands with the legs wide apart and the head down, and shows irregular spasmodic contractions of the leg muscles. The tail is flaccid; on walking the animal knuckles over at the fetlocks of both fore and hind limbs, frequently plunging head foremost on the ground after a short distance. Sensation is retained in the muscles. Rumination is suspended, but the animal feeds occasionally, and drinks fairly well. If cobs are still administered to the animal, the symptoms become more pronounced, and soon the animal is unable to stand on being lifted. It remains lying on the ground, feeding occasionally. Constipation now ensues, the fæces which are passed being coated with mucus which is blood-tinged. Death is preceded by a complete loss of tone of the muscles, the animal lying stretched out and comparatively limp.

If feeding on the mealie cobs is discontinued when well-

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marked clinical symptoms develop, recovery is fairly rapid. The appetite returns, and the animal feeds on green stuffs freely. The symptoms of paralysis disappear in a few days, but stiffness in movements persists for some time. In one case which recovered, knuckling over at the fetlocks continued for over a week when other symptoms had disappeared, and the animal developed a bony callus on the anterior aspect of the fetlock joints of the fore legs.

The temperature shows practically no alteration throughout the illness. The pulse is early affected, becoming rapid and thready, and, in the case which terminated fatally, almost imperceptible for the last two days of life.

Lesions on post-mortem:

In one case, which was available for examination, the chief lesions present were a well-marked catarrhal enteritis affecting the small and large intestines, acute diffuse hyperæmia of both kidneys, and well-marked congestion of both lungs.

Mortality:

The mortality varies considerably on the various farms. In some, practically all the animals which develop symptoms succumb, and in others a large percentage recover. It would appear that the mortality is greater in the latter part of the season.

Treatment.

No treatment was adopted in the case of the animals which recovered, and in which the disease had been artificially produced, other than good nursing. It is necessary to remove the animals at once from the lands as soon as the initial symptoms appear. Affected animals should be given a saline purge, so as to empty the intestines of digested irritant material. The animal should, if possible, be housed and given some green food, or, if none is available, an addition of a daily dose of linseed oil to the ordinary food as indicated.

Prevention.

Collection of all damaged cobs at the harvesting should be practised. As the suspected causal fungus is most prevalent in old mealie lands, these lands should be allowed to lie fallow for a few seasons, or, if this is impossible owing to lack of other suitable agricultural lands on the farm, strong measures should be adopted in order to get rid of the fungus itself on the lands. In view of the fact that the fungus had been demonstrated in the stalks, as well as in the cobs, it would be advisable to burn off all the vegetation in the lands as soon after the mealies were harvested as was possible. By this means complete sterilisation of the whole area would be ensured, and, in the following season, the cattle might be allowed access to the mealie lands with safety.

It is strongly recommended, however, whatever general treatment of the lands is carried out, that, on succeeding years, *all* cobs should be harvested.

THE SOUTH-WEST PROTECTORATE AND ITS NATIVE POPULATION.

By Rev. Professor W. A. Norton, M.A., B.Litt.

Read July 10, 1919.

On a journey to the Protectorate, I interested myself at the stations by asking the natives present to what nation and tribe they belonged, somewhat to the puzzlement of my fellow-passengers, and also sometimes to that of the subject, who seemed inclined to ask, like Raphael of Tobias, why I wanted a tribe and a family rather than a mere " boy " for some mundane service. However, I got from them, puzzled or not, the data for a table* of ethnographic distribution of our natives and those of the South-West. The outstanding facts about this are the following: The overflow of Colony Kaffirs (to use the Colonial term) into the Protectorate—a continuation of their immigration into the North-West districts of Cape Colony, which Cust notes by certain green spots on his 1883 language map; and the overflow of Ovambo from the Portuguese border as far as Walvis Bay, or even further south, also in search of work; finally, the ubiquity of the Klip-Kaffir (as the Berg-Damara are commonly called), and the surprising contrast between them and their old masters the Hottentots, whose language they speak. Their origin constitutes one of the problems of the land. They have no recollection or tradition apparently of any speech of their own, and yet, robust, cheerful, friendly, and black, they are ethnographically as distinct as possible from the slight and yellow Hottentot. Opinion tends to regard them as aboriginal, in possession when the Hottentot arrived, early (shall we say?) in the second Millennium after Christ: it is impossible to be more exact. All we know is that this interesting people—the Hottentots, not the Klip-Kaffirs—were at the Cape at the end of the 15th century to meet the Portuguese discoverers. The Nama Hottentots call themselves the Khoi-Khoin (Men of Men), but name the Klip-Kaffirs the Hau-Khoin, the dirty men, a particularly offensive term These are also called Berg-Damara, to distinguish them from the Hereros, who are the Cattle-Damara. Both these dark peoples, though quite unconnected, except that the Herero also held the Kaffir in subjection, were Dama (*ra* is a termination), in contrast to the Hottentot Nama, who again are distinguished from other Hottentots; the Korana, those of the Eastern Province, and the now extinct Hottentots of the Cape, with the somewhat mixed Griquas. The contrast between the pure Hottentot and the bastard settlers (at Rehoboth and elsewhere, about 1870)

* See Appendix II.

from Pella, De Tuin and Steinkopf, is very striking, and one realises how mixed the coloured population is at Cape Town. There is no possibility at Rehoboth of confusing the stalwart and often handsome bastard with the "Men of Men." To sum up our remarks on the inhabitants and their habitats: from the Orange to Windhuk is dry and rather forbidding after the pleasant places of the Western Colony. This is Great Namaqualand, inhabited by the Hottentots (thinly towards the coast), and by the Bastards round Rehoboth, some sixty miles south of the capital. Beyond this and northward to the 19th Parallel lies Damaraland with the Herero in the plains and the Berg Damara in the hills. This delightful district, green and varied, is backed by magnificent ranges and massifs (like Erongo, justly so named "the fine great place"), of which a wide view may be had from the square tower the Germans put up at Omaruru, to commemorate the Herero rebellion, or rather its ruthless quelling. Especially beautiful, northward of this point, was the country in January, reminding one constantly of the park-like land on the mainland opposite Zanzibar. I shall long remember a delightful trek I made in the company of congenial companions, thanks to the courtesy of the Magistrate at Tsumeb. We bivouacked for the night not far from where five leopards besieged a cart not long ago. At Grootfontein, the site of Jordaan's Republic of ill fate and short life, I was privileged to interview some Kalahari Bushmen who had been committed for murder. The poor things were trembling visibly, and seemed to think I was come to execute them. When, however, they were only required to name their head, eyes, hands, feet, etc., smiles appeared. Some physical anthropologists known to Cape Town had recently visited them, but had, I was told, no interpreter, and hence perhaps inspired the terror which greeted me. I was more fortunate in the service of a Hottentot woman who partly understood their dialect, but my success deserted me as soon as I left the concrete. I should mention that these so-called Bushmen are by no means diminutive. One was an exceedingly tall man, very light in complexion. It is well known that the Kalahari Bushmen are often full size. For those philologically interested, I append a vocabulary. (Appendix I.) Lions still occur in this district, especially at Namatoni, near Etosha-Pan. The flat plain was once a lake, and, in the wet season, still contrives to be largely a swamp. All success, all *possible* success, to Professor Schwarz in his scheme for making the desert rejoice, by the re-flooding of Etosha, Ngami, etc., if he only does it thoroughly enough to save us from expanded swamp. To the north again is Ovamboland, which really lies on both sides of the Portuguese border, hence the punitive expedition on the rebellion of Mandume, who could not understand how strangers could part their land by running a straight line through, in the form of a parallel of latitude.

These Ovambo are a fine people, at present unspoiled. Of their wide response to our labour market I have spoken before. Herero and Ovambo dialects are very closely related. The people themselves are much alike, and naturally good enemies. The country gradually becomes wilderness on either side. On the east of the Waterberg district, the Doorstveld and Groote Zand are inhabited by Bushmen; on the west (whatever relief the Kaoko-veld, through which the Hereros entered the land, may give), I do not know; but I can testify to the Namib between Usakos and Swakopmund as a howling desert of sand. Our troops could corroborate and emphasise this. One of the titles of Witbooi further south was "Lord of the Water," significant enough in a land of drought; yet Hottentots were found to inhabit the Namib. The Bushmen were formerly seen on its borders. I was driven to Usakos by the kindness of the Magistrate of Karibib, by way of Ameib, an interesting Bushmen site on the west side of Erongo. At the foot of an enormous natural column I saw, and roughly copied, a long procession of buck and other beasts, and hunters, done in the best Bushmen style. The neighbouring farmer who showed us the place, and whom I have to thank for two valuable books on the natives, was not a German, but a Luxembourger, son of a Papal Chamberlain, who was interned by the Germans at the beginning of the war, as having helped the English in the Boer war. Another farmer not far off was cousin to the prince bishop of Olmütz, late archbishop of Prague, whom I had met in 1912 in Bohemia. A far cry both in place and circumstance. It will be remembered that the Germans made an effort to introduce a "better-born" class of farmer in their later years of tenure.

Having described the country in relation to its native inhabitants, let me shortly sketch out the history of its occupation by Europeans.

The missionary, as usual, begins the story. In 1814 van Schmelen was sent by the Cape Government to Great Namaqualand, and moved from Bethany to Okahandja (called after him Schmelen's Hope), with Jager Afrikaner, who overcame the Herero in 1839. He married, like Van der Kemp, a Hottentot. By 1828 the last Cape Hottentots recrossed the Orange to the protection of the Red chiefs of Namaland. In 1840 the Rhenish mission arrived. In 1864 the Herero overcame the Hottentots, who had kept them so long under, by the help of European arms, this time helped, themselves, by the presence of Messrs. Green and Anderson. The latter's store was burnt in 1868, and also the Rhenish mission; hence appeals to the King of Prussia, two years before the Empire.

I propose to use, among other sources, the information which Mr. Lindholm, one of a family of early pioneers, was good enough to give me about his experiences. He was born at O'okiep at the date we have reached, and entered South-West

Africa from Walvis Bay in 1872. Meanwhile the Bastards, who had endeavoured to procure a settlement in the north-west of Cape Colony, and had been prevented by the farmers of the district and the Land Beacons Act, had sent to spy out the country, and arrived in force at Rehoboth, as aforesaid, at the time of peacemaking between Hottentots and Herero. They purchased their large territory there from the Hottentot chief Zwaartbooi for 100 horses at £25, and 50 wagons at £50 each. They have since increased by leaps and bounds. In 1876, when they were asking for Cape protection, as did the Hereros and several Hottentot tribes at the same time, Palgrave, the traveller, who was sent to report on the Protectorate, estimated their number at 1,500; now they number 3,000 to 4,000. In 1873 a trading company was formed for the benefit of the Rhenish mission. The idea was to get honest laymen, who could relieve the mission of the trade, which had almost inevitably grown up around their stations, and also to avoid the British traders. The missionaries found, however, that honest traders are not always easy to get, and some of them were opposed on principle to the policy. The Trading Company was liquidated in 1880. In 1878 Walfis Bay had been annexed. One cannot but pause to contrast German and British methods. Walvis with its wonderful harbour (then three weeks' voyage from Cape Town) is still but a number of huts on the sand. The neighbouring Swakopmund, much later occupied, is quite a fine town. But the Germans were not yet come: Luderitz, a Bremen merchant, arrived at Angra Pequena, since named after him, in 1882. The German flag was hoisted there on the 24th April, 1884, the Topnaar Hottentots making a grant as far as Cape Frio, with the exception, of course, of Walvis. Luderitz' agent was Mr Boehm, Snr. The remaining coast was sold by the Hottentot chief Fredericks, about the same time.

A German company was floated next year, and, at the same date, an interesting Dutch republic beyond the Waterberg began with the purchase of Upingtonia round Grootfontein from the Ovambo paramount chief, with mining rights at Tsumeb. A flourishing copper mine still exists here, which I descended by the courtesy of the manager. The mines were formerly worked by Bushmen, tributary to the Ovambo, who carried the ore home northwards. Jordaan, the founder of the republic, was murdered by a chief on the way to Mosammedes, and the republic in 1896 trekked on to Humpata in Angola. The Hereros thought Jordaan had sold the country to a South African company. Kama-Herero at the same time frightened away Göring. The Germans put it down to the British trader Lewis, who was believed to be in touch with Rhodes, and appealed to the Kaiser. In 1889 the two von François reached Okahandja and Omaruru, and Lewis left. In 1890 the Hottentots and Herero fell out once more. Hendrik Witbooi now learnt, to

his discouragement, that England had agreed to abandon them to Germany: his people were massacred in 1893 at Hoornkrantz, when he retired to the mountains. Leutwein arrived next year, and contrived eight agreements for surrender of land to German protection. The rinderpest broke the native powers in 1896, as elsewhere, and the following year the last Afrikaners of Warmbaths were shot, the Cape Government having given them up. We did not, however, thus treat our Herero refugees into Walvis and elsewhere in 1904.

In the century year Witbooi helped against the Bastards of Rietfontein. In 1903 the credit ordinances, ostensibly in the native interest, by refusing to recognise native debt, brought about sudden demands for payment by the European creditors and seizure of cattle, which were the Cattle-Damara's life, and one might say almost their gods. Indeed, it was the seizure of the sacred cattle, which were the finest, being kept for the ancestral spirits, which chiefly embittered the feeling and caused the rebellion which was so terribly quelled. It is true that four European women and one child stand among those commemorated on the fine monument of the slain upon Windhuk Hill, but von Trotha, fresh from his quelling of the Boxer rising, planned and largely effected the extermination of a people. It has been remarked that the missionaries seemed quite in the dark about what was brewing, though they had, of course, to suffer the reproach, "So much for your work amongst natives." Herr Olpp certainly writes very strongly of von Trotha in his *Kultur Bedeutung der Reinischer Mission* some years later, but none of us, I fear, made much protest at the time, missions or governments. It was, of course, difficult for those on the spot to protest, and for those away from the spot to discover the truth, till later.

The rebellion had become general, spreading to the Hottentots, the Hereros' old enemies. Hendrik Witbooi was killed in battle near Tses, and earned a really touching encomium from Governor Leutwein. His men rallied round his corpse and fought till it could be hastily buried. Jacob Marengo, his successor, was shot by the Cape police at Rietfontein; others fled to the Kalahari. The Bastards of Rehoboth claimed not to be used against Union troops in the present war, but in 1915 were required to guard prisoners, which they considered a breach of agreement. They were fired upon by the Germans, and suffered severely; but at last welcomed their deliverers. As the Herero are the tribe chiefly interesting to us, I conclude with a description of them I had from the pioneer settler mentioned above. They lived on sour milk (from September the weather was dry, and so cattle were slaughtered), also on mealies brought in by the missionaries, and on pumpkins, formerly on calabash and wild roots, for example, onions. Guns were traded in for feathers and ivory; the Herero sat in a hut to shoot the ostriches, which came for bitter melons; the Kalahari sort is tasteless.

The Herero in war wore tiger skins and bore assegais and two kerries; but these were not carried on horseback, when horses began to be used in fight against the Hottentots.

The women wore sheep-skin cloaks and a veil of sheep skin falling from the head behind, with three horns of raw leather above. The lower leg was covered with rings of iron beads, a skin well braised was also worn before and behind the waist.

The Hereros were too proud to work; they made the Berg-damara do so, except at Okambahe, where these were unmolested.

They worshipped two little sticks called ancestors, the male a wand of Ovampuvu and the female of wild plum; they placed daily milk gourds from the sacred cattle before them. Human pairs came from a tree at the call of a great magician, and animals also, but it was dark; the first Klip Kaffir, bungling, lit a fire, and the wild beasts fled away. But the Herero procured a bull and cow, and then all their languages were confounded. I thank the late magistrate of Omaruru for this and other information.

The Hereros lost their cattle in the rinderpest; they were gradually recovering it, by exchanging sheep, when the rebellion supervened. They produced no iron work, which was left to the Ovambo. The Ovambo to-day do not bury (except the Ndonga, whose chief, Martin, is a Christian). They put a reim round the leg, and drag the corpse from the village. Old lions ate them and developed a taste for human flesh.

I abstain from telling at length that, besides copper, gold and iron, are found in the Kaoko Veld, marble at Karibib, diamonds in the Namib, and that skins, also horns, oxen, feathers, guano are exported; or that there are so many kms. of telegraph wire, etc. Such things can be found in the encyclopedia. Game includes elephant, giraffe, and beasts of prey. The names Inyati-berg, Otjosonyati and the like, show that wild oxen once roamed. The land produces mealies, potatoes, figs, dates, wine, tobacco, and tree-wool: it should be worth caring for, notwithstanding its sandy wastes; indeed, it is in the sand that the diamonds are found.

Von Trotha's policy will be lamented for a very long time to come. The country is very short of labour, and the Herero, for example, are breeding very slowly, it is said through discouragement at their treatment. There is talk of the Bushmen being used, as they were beginning to be by the Germans, who, according to the Gorges report (which has taught me much), alienated them in the North by their treatment of their very prized womenfolk.

A word in conclusion of the more English coloured folk, who are apt to be omitted in a survey like the present, but whose families often have the most interesting history. One, long settled in the country, I found, which appealed to me ethno-

logically; a Hollander married a Buginese Malay; his daughter married a deserter from a man-of-war with a Dutch alias; *his* daughter, again, married the coloured son of a Hollander, and their son, an excellent and much-respected man, married the daughter of a Hottentot (half Griqua, half Namaqua). He was the heir to a peerage—so I was told, but I fancy a baronetcy. The heir's brother, a captain in the Royal Navy, landed one day, took the heir for a walk, and got him to renounce the title, and his son by another wife burnt his papers in a drunken fit.

Appendix I.

At Grootfontein my interpreter was a Hei//om Bushwoman. The tribal name is Nama for Bush-sleeper. The prisoners, whom I was kindly permitted by the authorities to interview, gave their names as Qgneisi, a Qouxa, Cui, a Ncamsib, and Cuñ, the same, all from Gcigcum, far away in the Government Farm direction. As Kaffir students are more frequent than those of Bushmen, I write the clicks as in that language so far as possible, but sometimes the click has to be placed before the qualifying *k, g*, etc., which really seem to have here a guttural force in Bushman: the phonetics of clicks, however, is too deep a subject to embark on here. The alveolar and labial (a kiss) remain ‡ and ʘ, as in Bleek. My English or German word was given the interpreter in the Nama Hottentot, which occupies the fourth column, as I heard it. The third column gives the Nama, as it appears in the vocabularies (Meinhof, Kroenlein, Seidel, represented by their initials). The fifth column gives the prisoners' Bushman version, again as I heard it, and the last column the Bushman forms collected by our sole surviving Bushman authority, Miss Doris Bleek, whose very generous help in the matter I beg most gratefully to acknowledge, and to the publication of whose great Bushman dictionary we all eagerly look forward. The first column gives a transcript of seSarwa made at Molepolole. It probably needs much revision, but is evidently very remote from the other Bushman, and even No. 4 below (*v.* stone, leopard). The acute accent represents stress, and usually high tone with it. Grave accents mean low tone.

I learn that Bushman falls into six groups, which are denoted by their numbers below:

1. South of the Orange, the cXam-ka qk'e, people of cXam (my *X* is the Du. *g*).

2. North of the Orange, from Rietfontein to the Vaal, the **xñ** (the second sound the ringing final of sing; vowels are nasalised with the same notation). These two named one another by the curse word Qnu, and spoke dialects as different as Du. and Germ.

3. On the Qnossop (W. Kalahari) the xnuna or Xatia.

4. Those under the Bechuana, called by their masters maSarwa.

5. Those by Lake Chrissie near Swaziland.

6. Those of Lake Ngami, the dialect nearest Hottentot. There were once Bushmen everywhere, including Natal and Basutoland, where they have left place-names, as Quthing and Qhoqholosing.

The Bushman words in brackets were collected by me from Fred Baartman, a very light Adam Kok Bushman from Hopetown, now a patient on Robben Island. I have felt it important to record what Bushman I found, though it is, of course, beyond my province and power.

baba	father	éib, dadáb	tataba	tataba	íbo, óa (3 fr. Du. Dada)
desa	mother	éis, mamás	mama	mama	Xóa (3 fr. Du. mama)
?gcam	sun	sores	soresa	qum	xoin
haiñ	wood	héib(S)	qkhas, qkás	qo	1. Θho: 2. Θbo: Θo (Langeburg): 5. Θho.
gxoa	stone	cuis (M)	ckuis	qnum	1. qkun: 4. qnum.
qhadu	lion	Xami	Xami	Xami	6. Xam.
qoé	leopard	Xámareb (game, K)	Xama	hamma	1. xkaue: 2. xkwe: 4. qhauñ, 6. qXau. (qhibe) *cf.* Suto nkwe, and ñau, wild-cat.
	cat				(qetn,=kitten)
	snake	càob	couba	qneiko	(kXàu)
	sheep	gu			(‡guru) *Cf.* Kaffir igusha
	ox	qamàb			(bañ)
	goat	birib			(b'li) Bleek writes burri M. *Cf.* Suto poli, but mBuzi widespread in Bantu
	Orange R.	Gqari-b (X.i Gqili)=River			reñ (qkXeñ)
ko-mácn	head	tanas	taná	qo (*cf.* wood)	Xu, cna
	hair	cùb (S)			ckukn (cukn)
hí	nose	‡guis	qoisa	tsuñ	cnuntu (cutu)
kqñ	tooth	xgub	qtu	tsauñ	xkheñ (xheñ)
ku-xé	ear	xnoub	cep	cui	qnuntu (weñtu)
koganí	chin	qgàni	qkum	gce	xhuñ
ko-dam	tongue	nami	num	tariñ	cerri (‡ánasi)
ko-tlam	mouth	ams	umqub	tseñ	6. tsi: 1. tu, ?Suto ho re "tu" (? touching mouth), be silent
ko-gxai	cheek	Xob	hodi	Xogi	qwei
qhai (pl. ko-qainedu)	eye	muñs		mora	tsaXau (tsaku)
ko-dum	neck	dómi, qáub (S)	umbi	tsa	qkhóu
ko-qwá	shoulder	qhos (M)	calata	qnodu	ckuñ cna, arm's head

ko-tsau (pl. tsani)	hand	qomi		qonona	cka (folld by cna means finger)
sam	breast	qus, fem. sami (M)	qus	gqoa	qkaXu (‡atu : *cf.* next)
hitsí	buttocks				
ca	belly	qnàb	qkupus	gxu	qkautu (axahi)
shi-qum	navel				
shi-conco	hips	‡howes (K)	tiñs		xkeisi (also feet, *cf.* Nama ‡èis, below)
shi-tenka	thigh				
shi-qoe	knee	xgoab	qwati	xkoa	3. xkoe (‡wan)
shi-xoró	back				
	legs	cnùb	cnoqu	comuna, qkoma	qkwa, lower leg: 6.
shi-qába	calf				qkó (‡oku, foot): 4. ckam
shi-qaré	foot	‡èis			
shi-qareqaré	toe	ckùnub (*cf. supra*)			
shi-qaretsí	heel	qnoás	noás	qoqoro	qnwa-qku, lit. foot's heel

N.B.— *Shi* and *ko* probably have the force of *my* and *thy*.

The Molepolole also gave:

kaross	loinskin	wallet	bracelet	leglet	hat
qau	kai*	pata	sonágui	qhai (below knee)	hutse (fr. Du. via Chwana)

*or *pudenda*, which was given as *shi-kai*.

Numerals: 1. (coi). 2. keésħa (cuka). 3. qunquichena (cnora).

Mosarwa at Serowe: 1. cuíye. 2. gamme. 3. ñevonai. 4. k'au tsaú (fingers of a hand).

APPENDIX II.

PLACE-NAMES AND ETHNOGRAPHIC ANALYSIS ALONG THE S.W.P. EXTENSION.

(The Hottentot names are in italics. The numbers in the margin give the latitude.)

	PLACE (suggested meaning)	TRIBES: Mpo.	Her.	Hott.	Klip-Kaffir,	etc.
19	Tsumeb (otyi-s-omeva, at the water)					
	Groot-fontein (tr. Hott. gei-coub)					
	Goab (?Qgoab, crack of whip, or ‡ab, arrow in Hott., or a Bushman name)					
	Guchab (?qu-Xab, Bushman, 2 foreheads, from the opposing precipices)	,,	,,	,,		Wild Bushman.
	Otavi (branch—wild fig-tree)	,,	,,	,,	,,	
	Kilo 475				,,	
	K-omu-kanti (at the feast)	,,	,,			
20	Oka-puta	,,	,,		,,	Bushman.
	Oka ve (great mountain)					
	Otyi-wa-rongo, *i.e.*, Mooiplaats		,,		,,	
	Kilo 357		,,			
	E-rondu (wide river)		,,		,,	
21	Otyi-ua (sharp kopjes)		,,			
	E-pako (pass between hills)		,,			
	Oma-ruru ("bitter" water; sulphur, iron) ...		,,	,,	,,	
	E-rongo Mt. (great place)		,,			formerly Bushmen.
	Kanona (a canon is preserved at Omaruru monument, but the name probably from yellow-berried bush *onona*)				,,	
	E-tiro (? Where men died)		,,			
	Onguati (doves)					
22	qKaribib (a bush so called)	,,	,,	,,	,,	
	Wilhelms Tal	,,	,,	,,	,,	
	Oka-thithe (much water)		,,			
	Oka-handya (midges)...	,,	,,		,,	
	O-siona (poverty)					

	Place (suggested meaning)	Tribes:	Mbo.	Her.	Hott.	Klip-Kaffir, etc.	
	Otyi-havero (seat) Windhoek (*cai-xgams*, fire-water, *i.e.*, hot-springs, so Warmbad) Popn. in order:		2	1	3	,,	Bastaard.
23	*Tsumis* (weak ground—sand sunk in?)						
	Marien Tal		,,	,,		,,	& baKoena of Monaheng fr. Quthing.

26 Broek-karos (leather breeched).
Itsawisi's (*Tsawib*, ebony tree : fem. ends -s) : Ovambo.
Keetmanshoop (‡*Nu goaes*, *i.e.*, Zwart Modder): Ndonga, Herero, Nama, Klip-Kaffir, a moTaung of Moletsane (since 1915), and a Kruman.
See Heim: Bondelschwarz.
27 Holoog (*xhoa-mus*, cave-eye, ? from cave or man)
C.C. Lutz-put (C. colrd., Tembu, Xosa, N.baRolong, Qkora-na and Griqua : Tlhapi, Koena of Sechele, Kgatla).
Klein-begin (Xosa)
Put-zonder-water (Xosa, Tembu, baRolong with Hott., Korana, Griqua, and Afrikaner's Bastaards).
Draghoender (dragoon), Bastaards and Xosa and Hottentot Griqua.
Prieska (with Bastaards and especially Xosa, and Qkora-na and Griqua) (the former Hott. tribe of Gordonia).
De Aar and Beaufort West with Griqua, and baSuto (S. Koena, Tsoeneng, Hlakoana).

I gratefully acknowledge the help of more than I can mention here. I obtained these data for names and population nearly all by personal enquiry, but shall be only too glad to be corrected and further informed. Place-names are a most delicate problem, and I may easily have omitted important elements of population here and there.

There are two interesting names I ought to add on the line to Walvis: one is Usakos (qusa-qkos), which means to bind the forehead with a fillet, or hoofs (even the learned Lutheran missionary at Karibib, who most kindly helped, could not be sure which "tone" *Qus* has locally), *e.g.*, with a reim. I wondered much what could be the origin of the name, fancying to myself some likeness in the skyline to a human face; till, one day, I approached from the north, and there, visible in the morning light, was an outcrop running all round the foot of the mountain like a wavy ribbon. The name was luminously cleared up.

The other name is Swakop, and refers, by a rather unexplainable simile, to the gush with which the river (when there is one at all; only after floods up-country) surmounts its bar. The first element of *Tsoa-Xoub* is *anus*. At ordinary times it is quite dry, though I was told an amusing story of former authorities ordering a ship to sail up the Swakop.

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INDEX OF SUBJECTS.

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1919.

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